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ABSTRACT

The goal of the Developmental Approaches in Science, Health and Technology (DASH) program is to preserve the curiosity and capture the imagination of all elementary students through an experience of science, technology, and health that engages them in the excitement of exploring and understanding the unknown, inventing and building to solve problems, becoming better able to care for themselves, and gaining basic meaningful knowledge that will enable further school study. This document contains a teacher's guide for 5th grade level. The document is divided into sections based on content. Activities include: (1) Learning; (2) Time, Weather and Sky; (3) Animals; (4) Plants; (5) Food and Nutrition; (6) Health and Safety; (7) Wayfinding and Transportation; (8) Energy and Communication, Conservation, Recycling, and Decomposition; (10) Matter, Space and Construction; (11) Activity Plans; (12) Scope and Sequence; (13) Material List; and (14) Complimentary Materials. Each lesson plan includes objectives, background, student role, required materials, product, and procedure information. (Author/YDS)

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ED 482 670

Grade 5
Teacher Guide

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DASH

Developmental Approaches in Science, Health and Technology

SE067332

Curriculum Research & Development Group
University of Hawai‘i

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DEVELOPMENTAL APPROACHES IN SCIENCE, HEALTH AND TECHNOLOGY (*DASH*) PROGRAM GRADE 5 TEACHER GUIDE

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DASH
PROGRAM LEARNING GOALS

The goals and objectives of DASH are included in the DASH Teacher Guides at each grade level. There are four tiers of goal statements in DASH. The overview, Tier 1, is the DASH program goal for students expressing the program's aspirations for students. At Tier 2 are fifteen program learning goals which categorize general kinds of learning DASH students at all grade levels should work toward to achieve the program goal for students. At Tier 3 are the DASH grade level activity learning goals that are specific for each activity and constitute subcategories of learning within the program learning goals. At the base, Tier 4, are the activity objectives that stipulate what the student should do to reach the activity learning goals. Listed here are the Tier 1 and Tier 2 program learning goals which embrace the entire program. Activity learning goals are found after each cluster's title page and the activity objectives are found within each activity of DASH grade level Teacher Guides.

The DASH program goal for students is to preserve the curiosity and capture the imagination of all elementary students through an experience of science, technology, and health that engages them in the excitement of exploring and understanding the unknown, inventing and building to solve problems, becoming better able to care for themselves, and gaining basic meaningful knowledge that will enable further school study.

The learning goals of DASH are to begin development of and increase students'

1. knowledge and understanding of the foundational concepts of the natural sciences.
2. knowledge and understanding of the concepts fundamental to maintenance of human health.
3. knowledge and understanding of the operations of the technologies.
4. knowledge and understanding of the connectedness of the sciences, technologies, and the needs of society.
5. abilities to inquire about the unknown in the world about them using the tools of science.
6. abilities to invent, design, make, and test solutions to problems.
7. abilities to use the knowledge of science, health, and technology in new situations.
8. abilities to apply language, mathematics, and pictorial conventions as they are needed in science, health, and technology studies.
9. abilities to work cooperatively, collaboratively, and independently as appropriate in science, health, and technology contexts.
10. commitment to the well-being of the natural environment.
11. commitment to the well-being of self and community.
12. awareness of the importance of personal learning about science, health, and technology
13. learning the ways of science, health, and technology for the excitement and pleasure they bring without concern for gender, ethnicity, or perceived ability.
14. readiness for the science experience of later studies.
15. appreciation for the contributions science, health and technology make to society.

DASH

GRADE FIVE
CLUSTER 1

Learning

5.1.1 The Learning Calendar
5.1.2 Responsibility
5.1.3 Library Check-Out
5.1.4 Library Check-In
5.1.5 Working Together
5.1.6 Things I Can Do for Myself and Others
5.1.7 Aphorisms
5.1.8 Friendship
5.1.9 Concept and Skill Inventory

ACTIVITY 5.1.1 THE LEARNING CALENDAR

OBJECTIVES

The students
- Record data for long-term studies in meteorology and astronomy.
- Record events of environmental, technological, and scientific importance.
- Record events that are of special importance to the class.

BACKGROUND

The DASH Learning Calendar is used at each grade level. It is designed to be a class science and technology log. In it are recorded
- data for long-term studies in meteorology and astronomy
- things learned and events important to the class
- unusual aperiodic events in the natural environment
- newspaper and magazine articles on happenings in science and technology

Long-Term Data Collection

DASH assumes that students learn through the experience of interpreting the world around them. Many phenomena can be interpreted effectively only after extensive data have been collected. This is particularly the case with meteorological and astronomical phenomena. In DASH the students collect data about the same phenomena over several school years, and each year their interpretation enlarges.

Changing Nature of the DASH Learning Calendar

In kindergarten through grade 2 the calendar record is normally highly pictorial to help the young students record and retrieve information more readily. Grade 2 or 3, depending on the development of the particular class of students, is a transition time for movement into a written recording mode. By grade 5 the record is predominantly a written one though the attractive pictorial method is also used for quick recognition of special events.

Things Learned and Events Important to the Class

As DASH activities are completed, a summary should be placed on the calendar. When appropriate, quantitative data should be recorded in graph form. As part of the mental health (self-esteem and interpersonal bonding) component of DASH, records should be kept of things that are important to individual students and to the class as a whole.

Aperiodic Events and Articles

To extend student interest in the world of scientific and technological achievements and occurrences involving natural phenomena, the students should be encouraged to add articles on current events to the calendar.

Form of the Calendar

It is suggested that very heavy long-carriage computer paper be used to make the calendar. This kind of paper will produce a record that can be pulled out to show a continuous record or used and stored as a book.

Storage of the Calendar

At the end of each school year the calendar should be stored in the library so that the data can be used in later classes.

The Grade 5 Calendar

Suggested calendar entries for grade 5 are shown in the following table. Where similar data have been collected in previous grade levels, the grade levels are identified under the column headed *Experience*. Finally, the approximate time when calendar items should be started is shown. See the key below for interpretation of the table.

KEY					
A	APRIL	F	FEBRUARY	My	MAY
AN	AS NEEDED	I	INTRODUCED	N	NOVEMBER
B	BEGINNING OF SCHOOL YEAR	Ja	JANUARY	O	OCTOBER
D	DECEMBER	Ju	JUNE	S	SEPTEMBER
E	EXTENDING	Mr	MARCH	*	APERIODIC EVENTS

GRADE 5
CALENDAR

CALENDAR ENTRIES	EXPERIENCE						START
	GRADE						
	K	1	2	3	4	5	
Date							
Day, month, week, year	I	E	E	E	E	E	B
Season (See Activity 5.2.6.)		I	E	E	E	E	B
Weather							
Temperature, Fahrenheit and Celsius indoors (See Activity 5.2.1.)	I	E	E	E	E	E	B
Temperature high and low outdoors (See Activity 5.2.1.)		I	E	E	E	E	SEPT &OCT
State cloudy, rainy, sunny, etc. (See Activity 5.2.1.)		I	E	E	E	E	B
Wind direction (See Activity 5.2.1.)		I	E	E	E	E	B
Wind speed (expanded Beaufort scale) (See Activity 5.2.1.)			I	E	I	E	B
*Rainfall (See Activity 5.2.1.)			I	E	E	E	SEPT &OCT
*Snowfall (See Activity 5.2.1.)				I	E	E	AN
Humidity (See Activity 5.2.1.)				I	E	E	B
*Wind chill (See Activity 5.2.1.)					I	E	AN
Clouds (See Activity 5.2.4.)					I	E	NOV
Fronts (See Activity 5.2.4.)					I	E	NOV
Weather maps, local (See Activity 5.2.3.)					I	E	NOV
Weather maps, national (See Activity 5.2.3)					I	E	DEC
Weather predictions (See Activity 5.2.3.)					I	E	NOV

CALENDAR ENTRIES	EXPERIENCE							START
	GRADE							
	K	1	2	3	4	5		
Astronomy								
Moon phase (See Activity 5.2.8.)	I	E	E	E	E	E		B
*Equinox, Solstice (See Activity 5.2.10.)			I	E	E	E		AN
Moonrise, moonset (See Activity 5.2.8.)			I	E	E	E		B
*Constellations rising and setting (See Activity 5.2.10.)				I	E	E		OCT
*Planets rising and setting (See Activity 5.2.10.)					I	E		OCT
Gnomon (See Activity 5.2.6.)					I	E		SEPT
Special Events								
*Birthdays (See Activity 5.1.1.)	I	E	E	E	E	E		AN
*School events (See Activity 5.1.1.)	I	E	E	E	E	E		AN
*Holidays (See Activity 5.1.1.)	I	E	E	E	E	E		AN
*Local catastrophes (See Activity 5.1.1.)	I	E	E	E	E	E		AN
*National catastrophes (See Activity 5.1.1.)				I	E	E		AN
*Health news (See Activity 5.1.1.)				I	E	E		AN
*Science articles (See Activity 5.1.1.)					I	E		AN
*Technology articles (See Activity 5.1.1.)						I		AN
Things Learned								
*Things learned in DASH	I	E	E	E	E	E	E	AN
*Things learned in other subjects	I	E	E	E	E	E	E	AN

Beginning the Calendar

Data collection should begin as early as possible in the school year. If wind indicators, rain and snow gauges, and other instruments needed for measurement are not available from the previous year, have groups of students make them for the class. If the students are new to DASH, have the entire class make the instruments.

Seasons

Fifth-grade students have dealt with seasons long enough to be able to color-code the calendar. They can give the edges of pages summer, fall, winter, or spring color stripes so that seasonal segments of the calendar can be identified when seen from the side.

If students have not had DASH 4, they can use Student Page 4.2.23 SEASONAL DATA to help them organize their data collection and interpret patterns of the seasons. See DASH 5 START-UP ACTIVITIES.

Data Collection and Recording

It is suggested that responsibility for making entries on the calendar be divided and groups of two or more students be assigned to each entry on the calendar for a week or so. See Activity 5.1.2 RESPONSIBILITY. This usually solves the problem of someone's being absent on the day of the assignment. By dividing the responsibility between several groups, more students can be regularly involved, and the class as a whole will have a greater sense of contribution. Further, "many hands make the work go faster." Students who have previously performed a task can teach those who haven't.

Sources of Astronomical Data

Astronomical data can be gotten from observation and newspapers and almanacs. Students who have had previous astronomical experience can practice their predictive skills by checking their predictions against published data.

STUDENT ROLES

Astronomer
Meteorologist
Chronicler

MATERIALS

Learning Calendar paper
Activity and Student Pages for 4.2.23 SEASONS AND THE SUN.
Activity and Student Pages for 5.1.2 RESPONSIBILITY
Activity and Student Pages for 5.2.1 WEATHER STATION

PRODUCTS

Learning Calendar

PROCEDURES

1. **Introduce the calendar by pointing out that again we will be collecting data each day for interpretation. List the information that is to be collected.**

   Date
   - Day, week, month, year
   - Season

   Weather
   - Temperature indoors—Fahrenheit and Celsius, high and low, A.M. and P.M.
   - Temperature outdoors—Fahrenheit and Celsius, high and low, A.M. and P.M.
   - Rainfall
   - Wind speed (Beaufort scale)
   - Wind direction
   - Weather—clear, partially cloudy, cloudy, rainy, snowy (Some areas will want to add smoggy.)
   - Humidity

   Astronomy
   - Sunrise, sunset
   - Planet rising and setting
   - Sun's zodiacal location
   - Moon phase
   - Moonrise, moonset
   - Gnomon readings

Special Events
- Birthdays
- School events
- Holidays
- Health news
- Local catastrophes
- National catastrophes
- Science articles
- Technology articles

Things Learned
- Things learned in DASH
- Things learned in other subjects

2. **Have the students make the instruments and logos they will need to maintain the Learning Calendar.**

   Have them devise
   - Rain gauges (See Activity 5.2.1.)
   - Wind direction indicators (See Activity 5.2.1.)
   - Logos for moon phases (See Activity 5.2.1.)
   - Logos for weather conditions (See Activity 5.2.1.)

3. **Have the students organize the Responsibility Chart so that there are assigned places for the items they are to record on the calendar. See Activity 5.1.2 RESPONSIBILITY.**

4. **Have the students lay out the organization of the calendar for recording. Start data collection and recording.**

EXTENSION

- Periodically roll out the calendar and review its contents.

ACTIVITY 5.1.2 RESPONSIBILITY

OBJECTIVES

The students
- Plan how to carry out classroom tasks.
- Record the completion of assigned responsibilities.

BACKGROUND

This is a follow-up to Activity 5.1.1 THE LEARNING CALENDAR. Because there are many projects and jobs in DASH, it is important that a record be kept of who is doing what. By grade 5 many students will have developed a high degree of responsibility and can be encouraged to take leadership and peer-teaching roles.

Management Team

It is suggested that management teams be formed to give leadership to different projects. Starting with the Learning Calendar, a management team should be involved in the organization and setting up of a class Responsibility Chart for record keeping.

Additional responsibilities for other activities can be added to or removed from the chart at any time. Most tasks should be rotated regularly. A time on Monday mornings or Friday afternoons should be set aside for checking the chart. Management roles, like all other tasks, should be rotated.

STUDENT ROLES

Planner
Worker

MATERIALS

Student Page 5.1.2 RESPONSIBILITY

PRODUCTS

Class Responsibility Chart
Completed Student Pages

PROCEDURES

1. **Discuss with the *management team* how they are to involve the class in developing a class Responsibility Chart.**

   Help the team recognize the need to discuss
   - Why we need a class Responsibility Chart.
   - Why it is important to keep a record of who does what jobs.
   - What jobs need to be done.
   - Why we should report or check off that we have done our job.
   - What happens when we do not do the things that we have agreed to do.
   - When jobs are to be done.
   - What we should do if someone is absent.
   - How we can monitor the job list.

2. **Have the *management team* develop a Responsibility Chart with the class.**

   Help the team include such things as these:
   - Daily responsibilities for maintaining the Learning Calendar.
   - Daily responsibilities for tending animals and/or plants.
   - Rotation of responsibilities.
   - Setting up a team to monitor job performance.

3. **As needed, have the *monitoring team* review the Responsibility Chart and how the work groups are doing their jobs.**

4. **As needed, have the *management team* add new responsibilities to the chart and remove those no longer applicable.**

EXTENSION

- Have the students report how jobs are assigned and monitored in the school cafeteria and principal's office.

Name________________________

Date________________________

STUDENT PAGE 5.1.2 RESPONSIBILITY

My responsibilities are listed below.

	DATE	
RESPONSIBILITY	STARTING	ENDING

ACTIVITY 5.1.3 LIBRARY CHECK-OUT

OBJECTIVES

The students
- Retrieve their Science Record Books and other records from the library.
- Review what they did in the previous grade.
- Review their questions that have not yet been answered.

BACKGROUND

In DASH it is important that there be continuity of conceptual development from grade level to grade level. As a device to help ensure this continuity, several records have been designed to be kept and transmitted from one grade to another. These include

• The Learning Calendar	(One copy kept in the library)
• The Working Dictionary	(One copy for each next-level teacher)
• The Wonder and Discover Book	(One copy for each next-level teacher)
• The Connections Book	(One copy kept in the library)
• Science Record Books	(Kept for each student in the library)
• Alcohol, Tobacco, and Drugs Scrapbooks	(One copy kept in the library)

The Learning Calendar

The Learning Calendar is a daily log of science data and other information. It can be kept in its box and made available to classes in subsequent years when they need seasonal, astronomical, and other data for comparison. This calendar collection is especially important in grades 5 and 6.

Working Dictionary

The Working Dictionary is a record of the class's evolving definitions of concepts and other terms. Ideally, it will be photocopied at the end of each school year and passed on to each teacher receiving DASH students at the next grade level. Fifth-grade teachers may receive several Working Dictionaries, broadening the richness of ideas to be rationalized as definitions continue to mature.

A working definition need not have a formal structure; however, it should incorporate a description of the object, process, operation, and so forth. The following are examples of working definitions:

- *Digestion* is a process of breaking down foods into their nutrient chemicals.
- A *pine tree* is a tree that is green all year, has needle-like leaves, and its seeds are found in cones.
- A *force* is a push or pull.

Wonder and Discover Book

The Wonder and Discover Book is a listing of students' questions that are still unanswered. Ideally, it also will be photocopied at the end of the year so that copies can be passed on to each next-level teacher receiving students from a DASH class. This record of ideas yet to be probed gives the students a sense of mission as they start the new year.

Connections Book

The Connections Book is an ongoing record of things the students have found that are related to their learning. The book can be kept in the library for students to use when they are curious about connections they have made earlier.

Science Record Books

The Science Record Books are the students' personal records of information that should be transmitted from one year to the next for long-term studies. They normally include such selected items as the following:

- personal growth charts
- personal dental records
- personal goals
- concept and skill self-evaluations
- records of such long-term investigations as decomposition studies, astronomical observations, observations of plants and animals, and seasonal change projects

Alcohol, Tobacco, And Drugs Scrapbooks

The Scrapbooks are collections of newspaper and other articles about drugs, tobacco, and alcohol. They should be kept in the library for students' use. See Activity 5.6.4 ALCOHOL, TOBACCO, AND DRUGS.

Ideally, the Science Record Books, the Wonder and Discover Books, the Connections Books, Scrapbooks, and the Working Dictionaries will be stored in the library over the summer and then checked out in the fall. If they are stored in the library, they should have a proper code number and library card for identification.

The retrieval of books from the library is intended to give the students a sense of the importance of their personal work and to reinforce the idea that science is based on the long-term collection of information. To emphasize its importance, the retrieval should be done with ceremony. This can be the time for the librarian to discuss the importance of the library as a repository of knowledge. After the retrieval the students should take time to review their records.

STUDENT ROLES

Scientist
Chronicler

MATERIALS

Science Record Books
Connections Books
Wonder and Discover Books
Working Dictionary
Student Page 5.1.3 LIBRARY CHECK-OUT

PRODUCTS

Completed Student Pages

PROCEDURES

1. **Explain to the students that we need to retrieve our Science Record Books, Connections Books, Wonder and Discover Books, Scrapbooks, and Working Dictionaries from last year.**

   Ask such questions as these:
   - Does anyone recall how we stored our books last year? (Get at the idea that we stored the books in the library after identifying them with a special code.)
   - Does anyone know how we can find out what that code is? (Probe for the idea that we also made cards for the card file and all we have to do is find our cards.)
   - Does anyone know how we can find our cards easily? (Help the students recall that the cards were filed alphabetically.)

2. **Work with the librarian to help the students retrieve their books.**

   Ask the librarian to
   - Get the DASH card file out so that the students can find their code.
   - Give a guided tour of the library's resources and explain how they can be used.

3. **Help the students review their grade 4 work starting with the Wonder and Discover Books.**

   Ask such questions as these:
   - Does anyone have answers to any of the questions left unanswered in the spring?
   - Who has new questions to add after the summer? (Add the questions. Suggest that interested students do additional research on the unanswered questions and share their findings.)

4. **Help the students review their Working Dictionaries. If the students have come from several different classes, have them rework their definitions for agreement.**

   Have the students
   - Work in teams with one or two definitions per team.
   - Join the definitions or state them as alternatives.
   - Report their findings to the class.
   - Modify their definitions as considered necessary by the class.

5. **Have the students go through their Science Record Books.**

   Help them review by asking such questions as these:
   - What did we do last year and what records do we have that help tell us what we did? (Work to the idea that the Concept and Skill Inventories help tell what kind of work has been done.)
   - Judging from last year's growth information, how much do you think you will grow this year?

EXTENSION

- Have the students report how banks, telephone companies, newspapers, post offices, and so forth keep their records.

DASH

Name____________________

Date____________________

STUDENT PAGE 5.1.3 LIBRARY CHECK-OUT

1. Record your personal research question.

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2. Report your findings in answering your research question.

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ACTIVITY 5.1.4 LIBRARY CHECK-IN

OBJECTIVES

The students
- Store their Science Record Books in the library.
- Make out cards identifying their books for the library files.
- Identify their Science Record Books with an appropriate code for easy retrieval.

BACKGROUND

At the end of the year keep essential information needed by sixth grade DASH teachers by storing it in the library or other designated repository. Items to be kept are listed below:

• Learning Calendar	(Copy kept permanently in the library)
• Working Dictionary	(One copy for each next-level teacher)
• Wonder and Discover Book	(One copy for each next-level teacher)
• Connections Book	(One copy kept in the library)
• Science Record Books	(Kept for each student)
• The Alcohol, Tobacco, Drugs, and Sexually Transmitted Diseases Scrapbooks	(One copy kept in the library)

The Learning Calendar can be kept in its box in the library. The Working Dictionary and the Wonder and Discover Book can be kept and photocopied in the fall once class assignments are known. The Connections Book can be kept in the library as a general resource.

Only parts of the Science Record Books need be kept. These are the students'
- personal growth charts
- personal dental records
- personal goals
- concept and skill self-evaluations
- records of such long-term projects as decomposition studies, astronomical observations, observations of plants and animals, and seasonal change projects

STUDENT ROLE

Science librarian

MATERIALS

Learning Calendar
Science Record Books
Wonder and Discover Book
Working Dictionary
Connections Book
Alcohol, Tobacco, Drugs, and Sexually Transmitted Diseases Scrapbooks
Student Page 5.1.4 LIBRARY CHECK-IN

PRODUCTS

Completed Student Pages

PROCEDURES

1. **Explain to the students that we need to store our Science Record Books, Wonder and Discover Book, Connections Book, Learning Calendar, Working Dictionaries, and Alcohol, Tobacco, Drugs, and Sexually Transmitted Diseases Scrapbooks for use next fall.**

   Explain that we will need to
   - Code our books using the system that our library uses to identify books. (Work out the code with the librarian ahead of time.)
   - Make cards for the card file so that we can find our books next fall.

2. **Work out a procedure with the students to code their books and make out the library cards.**

3. **Have the students present their books and cards to the librarian.**

EXTENSION

- Have the students research how books are electronically coded and shelved in large libraries.

Name________________________

Date________________________

STUDENT PAGE 5.1.4 LIBRARY CHECK-IN

SCIENCE RECORD BOOK
TABLE OF CONTENTS

ACTIVITY 5.1.5 WORKING TOGETHER

OBJECTIVES

The students
- Identify the cooperative nature of certain tasks.
- Write aphorisms about working cooperatively.

BACKGROUND

This activity is best introduced at the beginning of the year when the students are starting to take over the organization of their science work. The activity causes them to reflect on why some work is better done individually and some cooperatively. More important, it establishes some guidelines for working in groups and for working individually to produce things that others will use.

STUDENT ROLES

Manager
Psychologist

MATERIALS

Student Page 5.1.5 WORKING TOGETHER

PRODUCTS

Completed Student Pages

PROCEDURES

1. **Introduce the activity by having the students work in small groups to plan how to carry out one of the tasks listed in the table below. Give the groups five or six minutes to plan. They should assume that all equipment is on hand.**

   The groups will need to decide
   - How many people should be involved to carry out each task.
   - What each person should do to carry out the task.

Task 1	Prepare a garden plot 5 meters long and 3 meters wide for planting. This includes spading the soil, adding compost, and raking and leveling the soil. *Time:* 5 school days, 1 hour a day.
Task 2	Create and make a bulletin board mural 3 meters long and 1 meter wide showing the water resources of your community. *Time:* 5 school days, 1 hour a day.
Task 3	Invent, build, and install a vandal-proof platform bird feeder 60 cm x 60 cm outside your classroom window. *Time:* 3 school days, 1 hour a day.
Task 4	Design and carry out an experiment to see whether plants go through their life cycle without light. *Time:* 60 school days.
Task 5	Design and carry out an experiment to find the location of the hottest spot around a fire. *Time:* 45 minutes
Task 6	Design and carry out a survey of the families of your class to find the most commonly eaten breakfast cereal. *Time:* 3 school days

2. **Have each group describe its task, outline a plan for carrying it out, and tell the number of people needed to complete it in the time given. Have the students complete Student Page 5.1.5 WORKING TOGETHER.**

Ask such questions as these:

- Which of the tasks could be carried out by one person in the time given? (Probably Task 4 on the study of light. Enough time is given, and the task probably does not need several pairs of hands. Possibly Task 5 if the person could think of a quick way to make the test—using special thermometers, using metal strips, seeing how long it takes to melt wax, and so on.)
- Which of the tasks would require the most people? (The survey, Task 6, would probably require the entire class.)
- Is it likely that Tasks 4 and 5 would really be carried out by a single person with no help from anyone? How might other people be involved? (Work to the idea that most of the needed equipment probably would have been made by someone else—the

thermometers, metal strips, wax, containers for growing seed carrying water, and so on.)

3. **Have the students discuss the following statement about working together: "In our modern technological society everything we do in some way involves or has involved others."**

   Ask such questions as these:
   - Can you think of exceptions to this?
   - Were there any exceptions in the tasks we just analyzed?
   - What kind of responsibility does this place on us if we are making and doing things for and with other people? (Get at the idea that we must do the best we can because if we do a poor job, other people may not be able to carry out their tasks later on.)
   - What kind of responsibility does this place on us if we are working directly with others? (Get at the idea that we must work together as well as we can because if we don't work together, our shared project may fail.)

4. **Have the students use Student Page 5.1.5 to compose aphorisms about producing things for other people and working together.**

5. **Have the students periodically review their aphorisms after completing a task that required them to work with others and/or make things for someone else to use.**

   Ask such questions as these:
   - How did the task require you to work with others?
   - How did the activity require you to make something that others would use?
   - How well were you able to meet the intent of your aphorisms?

EXTENSION

Have the students ask their parents the following questions about working together:
- What do you do that involves working with others?
- What happens at your job when people don't work well together?
- What happens at your job when people work well together?

DASH

Name________________________

Date________________________

STUDENT PAGE 5.1.5 WORKING TOGETHER

1. Describe how your group organized to carry out the assigned task. List the number of people needed and what each would do.

2. Compose aphorisms to guide making products for someone else to use.

3. Compose aphorisms for working with other people.

ACTIVITY 5.1.6
THINGS I CAN DO FOR MYSELF AND OTHERS

OBJECTIVES

The students
- Identify their growing ability to be self-sufficient.
- Identify growing their ability to help others.

BACKGROUND

This activity continues the theme of self-sufficiency and community contribution started in kindergarten. It is designed to give the students an opportunity to set and monitor achievement of their own personal goals. The activity should be introduced reasonably early in the year. Ideally, the students will have access to the list of personal goals they set for themselves at the end of DASH 4 that were to be achieved over the summer. They should evaluate their previous goals and set new ones in DASH 5. The students' monitoring of the achievement of their goals should be done at the end of the semester or around New Year's and at the end of the school year.

There are two parts to the personal goal setting:
- things I want to do for myself this year
- things I want to do for others this year

The number of items listed by different students may vary widely. Number should not be a concern. What is important is that the students have goals that they can reasonably achieve. Additional goals can be added at the time of monitoring.

The monitoring can be done by using Student Page 5.1.6 THINGS I CAN DO FOR MYSELF AND OTHERS. The students rate themselves so that they can get a sense of how they are progressing in achieving their goals.

Rating Scale
There are two parts to the rating scale, ability and practice.

ABILITY	PRACTICE
1. I cannot yet do what my goal calls for.	1. I do not do what my goal calls for.
2. I can do what my goal calls for.	2. I sometimes do what my goal calls for.
3. I can do what my goal calls for and teach it to someone else.	3. I usually or always do what my goal calls for.

STUDENT ROLES

Self-sufficient person
Community contributor

MATERIALS

pencil
Student Page 5.1.6 THINGS I CAN DO FOR MYSELF AND OTHERS

PRODUCTS

Completed Student Pages

PROCEDURES

1. **If possible, have the students review their lists of personal goals they set at the end of DASH 4 for achieving self-sufficiency and community contribution. This will allow them to see how well they were able meet their goals over the summer.**

2. **Discuss some of the things that might be achieved during the coming year. List the students' ideas.**

3. **Help the students list their goals for the year on Student Page 5.1.5 THINGS I CAN DO FOR MYSELF AND OTHERS. These may include goals from previous years that have not yet been achieved. Honor students' wishes to keep some goals private.**

4. **At the end of the semester have the students monitor and reset their goals. Review the rating scales with the students.**

Ask such questions as these:

- What help, if any, do you need to achieve your present goals?
- What value is there in setting goals? (Discuss the importance of knowing what one wants to do. Knowing what one wants to do and setting goals are the first steps in eventually being able to do something.)
- Should we all have the same goals? Why? (Discuss individual differences in experience, interest, desires, and so forth.)
- Are there certain basic things that we all should try to do in school? Why? (Probe for such things as learning basic skills of reading, writing, and computing because we need these skills to learn about other things; learning about science, health, and technology because we need to know how things in our world work and how we can make them do what we want them to do; learning about the way we affect other people, the way other people affect us, and what we can do to get along well together.)

5. **At the end of the school year have the students again rate their achievement and set goals for the coming semester.**

EXTENSION

- Have the students research how goals are set in industry. This might be done by having a guest speaker.

Name________________________

Date________________________

STUDENT PAGE 5.1.6
THINGS I CAN DO FOR MYSELF AND OTHERS

Use the table to list your goals for helping yourself. At the end of the year, use the rating scales below to evaluate your achievement by circling the number that best describes your progress.

ABILITY	PRACTICE
1. I cannot yet do what my goal calls for.	1. I do not do what my goal calls for.
2. I can do what my goal calls for.	2. I sometimes do what my goal calls for.
3. I can do what my goal calls for and teach it to someone else.	3. I usually or always do what my goal calls for.

GOALS FOR MYSELF THIS YEAR

THINGS I WANT TO DO FOR MYSELF	ABILITY	PRACTICE
	1 2 3	1 2 3
	1 2 3	1 2 3
	1 2 3	1 2 3
	1 2 3	1 2 3
	1 2 3	1 2 3
	1 2 3	1 2 3
	1 2 3	1 2 3
	1 2 3	1 2 3
	1 2 3	1 2 3
	1 2 3	1 2 3
	1 2 3	1 2 3

Name ____________________________

Use the table to list your goals for helping others. At the end of the year, use the rating scales below to evaluate your achievement by circling the number that best describes your progress.

ABILITY

1. I cannot yet do what my goal calls for.
2. I can do what my goal calls for.
3. I can do what my goal calls for and teach it to someone else.

PRACTICE

1. I do not do what my goal calls for.
2. I sometimes do what my goal calls for.
3. I usually or always do what my goal calls for.

GOALS FOR HELPING OTHERS

THINGS I WANT TO DO FOR OTHERS	ABILITY	PRACTICE
	1 2 3	1 2 3
	1 2 3	1 2 3
	1 2 3	1 2 3
	1 2 3	1 2 3
	1 2 3	1 2 3
	1 2 3	1 2 3
	1 2 3	1 2 3
	1 2 3	1 2 3
	1 2 3	1 2 3
	1 2 3	1 2 3
	1 2 3	1 2 3

ACTIVITY 5.1.7 APHORISMS

OBJECTIVES

The students
- Review aphorisms about good social, health, and safety practices.
- Invent their own aphorisms about good social, health, and safety practices.

BACKGROUND

Throughout DASH the students are given wide exposure to recommended social, health, and safety practices. Because the list is large, reminding tools are needed to ensure that attention is given to these practices. One device is the *aphorism,* a pithy statement that captures a truth. Aphorisms can become so associated with our daily activities that they are triggered spontaneously at appropriate moments to remind us that some special action should be considered. Add aphorisms to songs, rhymes, raps, and jingles and we have a powerful arsenal of reminders.

DASH students are first exposed to aphorisms in kindergarten. In this activity the students review some aphorisms and rate their usefulness. They are then asked to find or make up their own aphorisms about good social, health, and safety practices.

STUDENT ROLE

Health consultant

MATERIALS

pencils
Student Page 5.1.7 APHORISMS

PRODUCTS

Aphorism Book
Completed Student Pages

PROCEDURES

1. **Have the students rate the usefulness of the aphorisms listed in Student Page 5.1.7 APHORISMS. Have them discuss the value of aphorisms as learning aids.**

2. **Have the students create or find additional aphorisms to cover current concerns of health and social and personal development.**

   Help them consider such things as these:
   - Procrastination.
   - Trying again after failure.
   - Doing one's best.
   - Integrity.
   - Respecting others.
   - Environmental concerns.
   - Social responsibility.
   - Drugs, tobacco, and alcohol.
   - Sexually transmitted diseases.

3. **Have the students make a class Aphorism Book and add new aphorisms when situations call for wise advice.**

EXTENSIONS

Have the students
- Ask their parents and others for their favorite aphorisms.
- Research the aphorisms of Benjamin Franklin and Mark Twain.

Name ____________________

Date ____________________

STUDENT PAGE 5.1.7 APHORISMS

Rate the aphorisms below in terms of their usefulness to you. Circle the *(U)* if the aphorism is USEFUL, the *(NU)* if the aphorism is NOT USEFUL.

1. Why should we eat right?

U NU Eat right, feel right, grow right.

2. What foods should we eat sparingly?

U NU Slow down sugar, slow down fat
A dash of salt is enough of that.

3. How much water should we drink in winter? In summer?

U NU Six glasses in winter and eight in summer
Are my body's natural plumber.

4. Why do we exercise?

U NU Exercise 20 minutes for strength,
30 minutes for endurance.

5. When do we put things away?

U NU Finished for the day?
Put things away.

6. To feel great how much sleep do we need?

U NU Sleep for eight,
Wake up feeling great.

SP 5.1.7-2

Name________________________________

7. When does one use the toilet?

U	NU	When nature calls, Listen and go.

8. How do we keep germs out our bodies?

U	NU	Mouth in the water, Not on the fountain.
U	NU	Someone else's dishes are someone else's germs.
U	NU	Wash hands before eating or fixing a hurt, After using the toilet or working in dirt.
U	NU	Every wound requires inspection. Untreated wounds invite infection.

9. How do we take care of our teeth?

U	NU	Brush twenty times up And twenty times down, Inside, outside, all around. Floss in between To complete the routine.

10. How do we keep our skin and hair healthy?

U	NU	Healthy skin and hair are clean skin and hair.

11. How do we keep from spreading germs when we are sick?

U	NU	Don't sneeze or cough with the cover off.
U	NU	When sick, stay home. Don't let your germs roam.

SP 5.1.7-3

Name______________________________

12. Why should we stay away from alcohol, tobacco, and drugs?

U NU A smoker's a croaker.

U NU There's no excuse for drug abuse.

U NU Alcohol makes your system stall.

13. What does one do in emergencies?

U NU Remember 911
When emergencies come.

14. What kind of clothes should we wear in winter? In summer?

U NU Dark clothes feel comfortably warm.
Light clothes feel comfortably cool.

15. What color should we wear when walking at night?

U NU Wear white at night.

16. How should we keep our work environment?

U NU A clean and safe space
Is a great workplace.

17. What do concerned and caring people do for others?

U NU Sharing with others is caring for others.

18. How do we handle responsibilities?

U NU Get the job done
Then have fun.

19. When should we help others?

U NU Lend a hand
When you can.

Name______________________________

20. How do we make friends?

U NU To gain a friend, be a friend.

21. How do we play games?

U NU Play fair with others and they'll play fair with you.

22. Why are we in school?

U NU School is for today and tomorrow.

23. How can we test what we think we know?

U NU If you really know and understand,
Teach and give someone else a hand.

24. How do we treat other living things?

U NU Respect all living things.

25. How can we meet our goals in life?

U NU Plan AHEAD.

26. What do we include in a reference citation?

U NU When writing a reference citation we look to see
That we have a double *A* and a triple *P*.
Author and Article account for double *A*.
Page, Publication, and Publisher complete the display.

Name________________________________

27. Why do we need to conserve our resources?

U	NU	Waste not, want not.

U	NU	What we save today we have tomorrow.

U	NU	Conserve our precious gas and oil And work to save our coal and soil. When they're gone there will be no more. Remember they're things we can't restore.

28. Why should we recycle things?

U	NU	There's a need to recycle the things that we use. Wasting resources we cannot excuse. Paper and brass, Aluminum and glass, Their value through recycling they never do lose.

29. Why should we look for errors in our work?

U	NU	Errors are common in all that we do. Knowing we make them should sharpen our view Of our speaking and writing and thinking too.

ACTIVITY 5.1.8 FRIENDSHIP

OBJECTIVES

Have the students
- Act out playlets that stress friendship.
- Analyze the actions of the characters.
- Attempt to develop friendship-mending conclusions for the playlets.
- Reflect on friendship as satisfying our social instincts.

BACKGROUND

Friendship is one of the great binding forces of society. It provides firsthand experience in how others think and respond to the world and is an important humanizing factor in growth and development. Like many dimensions of mental health, friendship is easiest to discuss in the context of third-party experience.

In the first part of the activity, the students are presented with five playlets in which a friendship is put in jeopardy. They are asked to work in groups to devise concluding scenes to resolve the conflict and save the friendship involved.

In the second part of the activity the students make a concept map of the term friendship to help analyze the kinds of social bonds they have dealt with in the playlets. They are then asked to assume the role of Alice Helpin, a newspaper advice columnist, and write a reply to a letter from one of her troubled readers.

STUDENT ROLES

Actor
Psychologist

MATERIALS

Student Pages	5.1.8 A FRIENDS 5.1.8 B FRIENDSHIP

PRODUCTS

Playlets
Completed Student Pages

PROCEDURES

1. **Have teams act out and complete each of the dramatic playlets outlined below. Have the class work in teams to write a friendship-saving story for each playlet.**

Playlet 1

Prolog
Lonnie had been Mona's friend since the third grade when Mona first came to Campbell Elementary School. In the third grade Mona was new to the school and a couple of the girls started to tease her because she couldn't jump rope.

It was then that Lonnie, who couldn't jump rope either, made Mona her friend. The two have been inseparable until this morning when David Bason asked Mona if she wanted to have a soda with him. Mona was with her family at the mall. She had twenty minutes before the family was to gather in front of the Hasty Market, so she said, "Sure." While they were sitting and talking, Lonnie passed by, took one look, and retreated in tears. Mona didn't even see her.

David is Mona's next-door neighbor. Every time Lonnie is at Mona's house and sees David she tells Mona how much she likes him. It is now seven o'clock and Mona arrives at Lonnie's to watch a video and spend the night, something she often does on Saturdays. Mrs. Kentz meets Mona at the door, tells her that Lonnie is in her room, and goes back into the kitchen.

Scene - Lonnie confronts Mona

Have teams of students act out the confrontation between Lonnie and Mona.

Last speech:
Lonnie: I don't want you in my house ever, ever again.

A. Have the class analyze the confrontations.

Ask such questions as these:
- What were Lonnie's feelings?
- What role did their past friendship play in the way Lonnie felt?
- What reasons could Mona have had for accepting Dave's invitation?
- What role should her friendship with Lonnie have played?
- Can friendship survive competition? How?

B. Have teams of students write stories in which Lonnie and Mona's friendship is saved.

C. Have the class analyze the stories.

Ask such questions as these:
- What motivated the re-establishment of the friendship?
- What did Mona and Lonnie have to do to save their friendship?
- How are the stories different? How are they similar?
- Was the friendship worth saving? Why?

Playlet 2

Prolog

Will and Jess met at a summer camp when they were seven. They were in the same bunkhouse. It was then they discovered that they lived only a block from each other and had never met because Will went to Samuelson Elementary and Jess went to Henderson Elementary. They since have played on teams together and now spend a lot of time playing Jess's expensive video games.

Will has a magnetic latch on his school book sack. Jess's mother told the boys not to get magnets close to the video game, but Will forgot and put his bag on top of the desk. Now Super Turtle II and Birthday Blowout don't work.

Scene - Jess confronts Will.

Have teams of students act out the confrontation between Will and Jess.

Last speech:
Will: I can't and won't pay for them.

A. Have the class analyze the confrontations.

Ask such questions as these:
- How does Jess feel? Why?
- How does Will feel? Why?

B. Give further information: ***Will comes from a family of six children who live with his mother at his grandma's house. His mother works days as a waitress. Jess is an only child. His mother and father both teach.***

C. Have teams of students write stories in which Jess and Will's friendship is saved.

D. Have the class analyze the stories.

Ask such questions as these:
- What motivated the re-establishment of this friendship?
- How did understanding play a role in the story?
- What role did the families play in the story?
- Was the friendship worth saving?

Playlet 3

Prolog
The three Honigin and three Santos kids have lived in the same apartment complex as long as they can remember. They are the same ages. They play together all through the summer, go to school together through the fall, winter, and spring, and attend church together on Sunday.

Juanita is Helen's very best friend. One day Juanita tells Helen that Craig, Helen's younger brother, has started smoking. Juanita adds that she has told her mother because she, Juanita, worries about Craig. They know Mrs. Santos will pass this on to Mrs. Honigan.

Scene - Helen confronts Juanita.

Have teams of students act out the confrontation.

Last speech:
Juanita: Craig's my brother, not yours. You have no right to tell on him.

A. **Have the class analyze the stories.**

Ask such questions as these:
- How does Helen feel? Why?
- How does Juanita feel? Why?
- How do you view what Juanita did? Was she right in doing it?

B. **Give the following additional information: *Both Mrs. Santos and Mrs. Honigan smoke. When Helen and Juanita tell their mothers about their fight, it is decided to get both families together.***

C. **Have teams of students write stories in which the friendship of Helen and Juanita is saved.**

D. **Have the class analyze the stories.**

Ask such questions as these:
- How are the stories similar? How are they different?
- What role did friendship play in the story?
- What role did family unity play?

Playlet 4

Prolog
Ron was in a car accident last year. For a long time he was in a wheel chair and had three operations to rebuild his leg. Millie and Drake live next door and have been friends with Ron since they moved to Willow street five years ago. Before the accident they all played street games with the neighborhood kids. Now Ron sits on the porch sometimes but doesn't try to play. He did try several months ago, but his leg felt as if had nails in it. When he missed a fly, Velma Banks shouted, "Limpy, gimpy, he's too wimpy to even try." Ron

hasn't been "in the street" since. Ron now stays in at recess and lunch and reads because his leg "hurts too much."

This afternoon Ron's mother dropped him off at home from school, and he limped to the porch where he sat down and just looked at the fall leaves and the darkening sky. Then Millie came over to ask whether he had a copy of the math homework assignment and would like to play a game with her.

Scene - Ron blows up at Millie.

Have teams of students act out the explosion.

Last speech:
Millie: Ron Washington, you used to be my friend. I don't care if your leg does hurt. You just can't treat people that way. We have feelings too, you know?

A. Have the class analyze the stories.

Ask such questions as these:

- How does Ron feel? Why?
- How does Millie feel? Why?
- How did Velma feel? Why?
- How do you view what Ron did?
- How do you view what Millie did?
- How do sick or physically challenged people feel when someone taunts them?
- Have you ever felt unhappy and found yourself lashing out at people around you?
- When we are feeling unhappy, how can we keep from souring the world of those around us?

B. Have teams of students write stories in which the friendship of Ron and Millie is saved.

D. Have the class analyze the stories.

Ask such questions as these:

- How are the stories alike and different?
- What kinds of changes in behavior were suggested for Ron? For Millie?
- How realistic are the solutions?

Playlet 5

Prolog

Mrs. Vance's class is the friendliest class in Martha White Elementary School. Or so says Mrs. Vance. She tells everyone: "My children have been together all their lives. Contrary to that old saw 'familiarity breeds contempt,' they work well together, make up for each other's deficiencies, and just plain like each other."

Palone Solsman was put in Mrs. Vance's class last month. She came from the small Pacific island of Tubai where her father was a Peace Corps teacher. Mrs. Vance had Palone tell all about her island, and the class found it on map of the Pacific. She then assigned Jack and Jennifer to be her "special friends." One afternoon several weeks later Jennifer asked Mrs. Vance whether Sessy Brown could switch places with her.

"What do you mean?" asked Mrs. Vance.

"I'll take over Sessy's job of window monitor, and Sessy can be Palone's special friend. I've asked her, and she says she likes strange people."

"What do you mean by strange?"

"You know. Palone really doesn't listen to me when I'm helping her. Besides, I can't understand what she is saying most of the time, and she always wears those real long old skirts."

"I believe we should think about this," said Mrs. Vance. "Let's talk about it tomorrow." Mrs. Vance had to see the principal right after school about the field trip.

On her way home from school, Jennifer was walking with a group of others in her class when she looked on the other side of C street and saw Palone grab her little brother Pango by the arm. Palone started to pull him along, and he began to cry. Unhesitatingly she slapped *him. He stopped crying and walked meekly behind her. Jennifer bounded across the street confront Palone for her cruelty.*

Mrs. Vance was driving down C Street when she saw a group of "her" children. It looked like a fight. She wheeled into a driveway.

Scene - Mrs. Vance, Palone, Palone's little brother, Jennifer, and a crowd of classmates.

Have teams of students act out the confrontation between Palone, Jennifer, and Mrs. Vance.

Last speech:

Mrs. Vance: You're all acting like a mob. What's happened to your sense of friendship? Go home this instant, and we'll see about this tomorrow.

A. Further information: ***Unknown to Jennifer, Palone has taken care of Pango since he was a baby, and on Tubai use of physical force was the way older children were expected to deal with their siblings. Palone's long dresses were considered a sign of modesty on Tubai.***

B. Have the class analyze the stories.

Ask such questions as these:

- How does Jennifer feel? Why?
- How does Palone feel? Why?
- How does Mrs., Vance feel? Why?
- Are the children in Mrs. Vance's really friends?
- What did Mrs. Vance mean when she said people were acting like a mob?
- What happens in a mob? Why might people in a mob do things they would never do individually?
- How does difficulty in understanding someone else affect people?
- How do differences in appearance affect us?
- Why is it difficult for some to join a group that is already established?
- How would you feel if you saw Palone strike her brother?
- Are there things that some people find to be improper behavior that others don't?

- Are there things that everyone agrees are unacceptable behavior?

C. **Have teams of students write stories in which friendships between Palone and the other members of Mrs. Vance's class are established.**

D. **Have the class analyze the stories.**

Ask such questions as these:
- How are the stories alike and different?
- How could the class get to know Palone better?
- How could Palone get to know the class better?
- What kinds of changes in behavior were suggested for Palone? Jennifer? Other members of the class? Mrs. Vance?
- How realistic are the solutions?

2. **Have the students make a concept map of the term friendship.**

Help them include such things as these:
- Enjoyable.
- Understanding.
- Forgiving.
- Considerate.
- Protective of another's interests.
- Common interest.
- Reliable.
- Available in time of need.
- Common problems.
- Sharing.

3. **As individual work have the students take the role of Agnes Helpin, a newspaper advice columnist, and use Student Page 5.1.8B FRIENDSHIP to answer one of the letters she has received.**

- Dear Miss Helpin,
  I have just moved to a new neighborhood and none of the kids like me. In my old neighborhood I knew all the kids and we had lots of fun. How can I make friends?
  (signed) LONELY

- Dear Miss Helpin,
  My best friend has just moved away. We were always together, and now I have nobody except my little brother to talk to. What can I do?
  (signed) LOST

- Dear Miss Helpin,
  I asked my aunt to write you because I don't write English. My question is How can I make friends? I'm in an American school and can't speak English?
  (signed) SPEECHLESS

- Dear Miss Helpin,
  My best friend is mad at me because I don't like to party with some of the other kids. They sometimes get beer and wine, and my family doesn't think that's right. What can I do?
  (signed) CONFUSED

4. **Engage the students in reflections on friendship.**

Ask such questions as these:

- How does the length of time we humans are taught by adults about the world around us compare with the time that insects, fish, mice, or dogs are taught before they are on their own? (Get at the idea that in most cases we are being taught for 15 to 30 years before we are fully on our own. The insects and fish must know immediately what to do after hatching or they will not survive while a mouse pup is taught a week and a puppy dog for less than a year.)
- If the insects and fish are not taught, how might they know what to do? (Have the students hypothesize. Work to the idea that they must have some information built into their brains that helps them survive from the moment the emerge from their eggs. Give that information the name "instinct.")
- Can you think of instincts that we humans might have? (Get at the notion that we have instincts to eat, drink, breathe, eliminate, sleep, exercise, seek warmth, learn, and to explore from birth. Note also that these satisfy our basic biological needs.)
- We also seem to have a strong social instinct. What do you think that means? (Work to the idea that we seem to need the presence of other humans.)
- How might friendship be a way of satisfying our social instinct? (Play with such ideas as it gives us a way of being with others

and not fighting and it gives us a way of learning from others. Point out that our natural instinctive curiosity drives us into constant learning, and learning takes place in social surroundings.)

EXTENSIONS

- Have the students compile a list of friendships from literature and the problems the characters had to overcome.
- Have the students create letters to Miss Helpin and have groups answer them.
- It has been said that our most precious instinct is the instinct for friendship. Have the students defend this observation or present an argument against it.

DASH

Name________________________

Date_________________________

STUDENT PAGE 5.1.8A FRIENDS

Write a happy ending to a playlet in which your characters save their friendship.

DASH

Name______________________

Date______________________

STUDENT PAGE 5.1.8B FRIENDSHIP

Assume the role of Agnes Helpin, advice columnist, and reply to one of the letters that have appeared in her column.

- **Dear Miss Helpin,**
  I have just moved to a new neighborhood and none of the kids like me. In my old neighborhood I knew all the kids and we had lots of fun. How can I make friends?
  (signed) **LONELY**

- **Dear Miss Helpin,**
  I asked my aunt to write you because I don't write English. My question is How can I make friends? I'm in an American school and can't speak English.
  (signed) **SPEECHLESS**

- **Dear Miss Helpin,**
  My best friend has just moved away. We were always together, and now I have nobody except my little brother to talk to. What can I do?
  (signed) **LOST**

- **Dear Miss Helpin,**
  My best friend is mad at me because I don't like to party with some of the other kids. They sometimes get beer and wine, and my family doesn't think that's right. What can I do?
  (signed) **CONFUSED**

Dear ______________________

ACTIVITY 5.1.9
CONCEPT AND SKILL INVENTORY

OBJECTIVES

The students
- Assess their understanding of selected concepts.
- Assess their ability to perform selected skills.

BACKGROUND

This activity is a continuation of the DASH assessment component that begins in kindergarten and extends through the sixth grade. The activity is designed to make the students aware of concepts in DASH they understand and skills they have mastered so that they can monitor their own work and achievement. The instrument used is called the Concept and Skill Inventory.

Concepts

The term *concept* is used in DASH to refer to the ideas and connections captured in a word or phrase. A concept in DASH is a growing thing. A kindergartner's concept of seasons, for example, is less rich than a fourth grader's.

In grade 5 the students distinguish *four levels* of understanding with teaching as the highest level of achievement.

CONCEPTS

0 No understanding of the concept
1 Beginning to understand the concept
2 Good understanding of the concept
3 Can teach someone else the concept

Skills

The term *skill* in DASH refers to the ability to gain and use knowledge or perform learned physical tasks effectively. In the fifth grade, DASH skills are divided into three categories: mechanical/intellectual, interpersonal, and motivational. A skill, too, is a growing thing; for example, a fifth grader normally is able to measure mass with much greater precision and accuracy than a second grader.

Mechanical/intellectual skills—The term refers to the ability to manipulate equipment and process information.

MECHANICAL/INTELLECTUAL SKILLS
0 No evidence of the skill
1 Beginning to use the skill
2 Good use of the skill
3 Can teach someone else the skill

Interpersonal skills—The term refers to the demonstrated ability to relate to others.

INTERPERSONAL SKILLS
0 No evidence of the skill
1 Beginning to use the skill
2 Good use of the skill
3 Can teach someone else the skill

Motivational skills— The term refers to the demonstrated ability of a person to achieve self-directed goals.

MOTIVATIONAL SKILLS
0 No evidence of the skill
1 Beginning to use the skill
2 Has good use of the skill
3 Can teach someone else the skill

This part of the inventory gives the teacher the most insight into how the students think about themselves. Whether to include it with any permanent records is left to the teacher's discretion.

Use of the Instrument

It is suggested that the teacher and the students use the inventory independently to rate concepts and skills. Discrepancies can then be resolved by discussion. If there are questions about rating differences, the students can be asked to teach the concept or skill to the teacher. The level of understanding will readily emerge. The students should be encouraged to refine their understanding and skills by attempting to teach others.

Concepts and Skills Not Covered

Students may not get to explore all the concepts and skills listed on the inventory in the school year. This should not limit the use of the instrument. Some students will gain understanding of concepts and skills outside formal instruction and should be credited for such learning. Concepts or skills that have not been presented in class can be considered as goals for future learning.

Additional Concepts and Skills
The concepts and skills listed in the instrument are but a sampling. The teacher may make additions, substitutions, or deletions as needed.

Reporting
The Concept and Skill Inventory can be used as a reporting instrument for the home and school. If it is used as a replacement of standard reporting forms, some communication should accompany the inventory describing how it should be interpreted.

STUDENT ROLE

Evaluator

MATERIALS

Student Page 5.1.9 CONCEPT AND SKILL INVENTORY

PRODUCTS

Completed Concept and Skill Inventories

PROCEDURES

1. **Discuss the purpose of Student Page 5.1.9 CONCEPT AND SKILL INVENTORY.**

   Include such things as these:
   - The inventory allows students to tell what they think they know.
   - The inventory allows teachers to check their personal observations with those of students.
   - The inventory indicates what is already known and what has yet to be studied.

2. **Work with the students to develop working definitions of important terms.**

Include the following:

- **Concept**. (Work to the idea of the connections that are captured in a word or phrase. A concept includes definitions and associations and may include such things as identification of parts, operation of parts, uses, and differences between and likeness to other things.)
- **Skill**. (Work to the idea of an ability to gain and use knowledge effectively or perform some learned physical feat.)
- **Interpersonal**. (Work to the idea of working together.)
- **Motivation**. (Work to the idea of a drive to achieve a personal goal.)

3. **Go over examples of each section of the inventory. Read the instructions with the students and answer any questions.**

4. **Privately discuss any differences between your perception of students' understanding and performance and their own.**

5. **Have the students keep the completed inventory in their Science Record Book.**

EXTENSION

- Have the students keep a list of additional concepts and skills they have mastered.

TEACHER RECORD
DASH FIFTH GRADE CONCEPT AND SKILL INVENTORY

CONCEPTS	NAMES OF STUDENTS														
KEY 0 Has no understanding of the concept 1 Is beginning to understand the concept 2 Has good understanding of the concept 3 Can teach someone else the concept															
1. Cloud types															
2. Weather maps															
3. Weather fronts															
4. Wind chill															
5. Heat index															
6. Gnomon															
7. Ecliptic															
8. Celestial equator															
9. Constellation															
10. Longitude															
11. Latitude															

CONCEPTS contd

NAMES OF STUDENTS

KEY 0 Has no understanding of the concept 1 Is beginning to understand the concept 2 Has good understanding of the concept 3 Can teach someone else the concept															
12. Right ascension															
13. Declination															
14. Greenwich															
15. Fulcrum															
16. Resistance															
17. Effort															
18. Wheel-and-axle															
19. Inclined plane															
20. Block-and-tackle															
21. Force															
22. Food Pyramid system															
23. RDAs															

CONCEPTS contd

NAMES OF STUDENTS

KEY 0 Has no understanding of the concept 1 Is beginning to understand the concept 2 Has good understanding of the concept 3 Can teach someone else the concept															
24. Nutrient															
25. Male urogenital system															
26. Female urogenital system															
27. Ovum and sperm															
28. Cells															
29. Embryology															
30. Sexually transmitted disease															
31. HIV/AIDS															
32. Addiction															
33. Alcohol Blood Level															
34. Energy															
35. Muscle system															
36. Skeletal system															

CONCEPTS contd

NAMES OF STUDENTS

KEY 0 Has no understanding of the concept 1 Is beginning to understand the concept 2 Has good understanding of the concept 3 Can teach someone else the concept															
37. Eye															
38. Ear															
39. Sound															
40. Erosion															
41. Tap and fibrous roots															
42. Trees and shrubs															
43. Volume															
44. Mass															
45. Light															
46. Magnification															
47. Annual/perennial plants															
48. Metric system															
49. Technology															
50. Science															

MECHANICAL/INTELLECTUAL SKILLS

	NAMES OF STUDENTS														
KEY 0 No evidence of the skill 1 Is beginning to use the skill 2 Has good use of the skill 3 Can teach someone else the skill															
1. Diagram devices to show structure															
2. Make a balance Use a balance															
3. Make a metric rule Use a metric rule															
4. Make a graduate Use a graduate															
5. Use a Planetarium in mapping the sky															
6. Make a telescope Use a telescope															
7. Make a microscope Use a microscope															
8. Identify local birds															

MECHANICAL/INTELLECTUAL SKILLS contd

	NAMES OF STUDENTS														
KEY 0 No evidence of the skill 1 Is beginning to use the skill 2 Has good use of the skill 3 Can teach someone else the skill															
9. Identify local trees															
10. Determine the height of trees															
11. Design and set up a controlled experiment															
12. Consider proper number of organisms used in experiments															
13. Solve problems by the invention of devices															
14. Solve problems by the invention of techniques															
15. Make a hygrometer Use a hygrometer															
16. Identify different cloud types															

MECHANICAL/INTELLECTUAL SKILLS contd

	NAMES OF STUDENTS														
KEY 0 No evidence of the skill 1 Is beginning to use the skill 2 Has good use of the skill 3 Can teach someone else the skill															
17. Determine wind chill															
18. Determine heat index															
19. Use latitude and longitude in map reading															
20. Make weather predictions															
21.															
22.															
23.															
24.															

INTERPERSONAL SKILLS **NAMES OF STUDENTS**

KEY 0 No evidence of the skill 1 Is beginning to use the skill 2 Has good use of the skill 3 Can teach someone else the skill															
1. Carry out responsibilities															
2. Share things															
3. Wait turns															
4. Have patience with others															
5. Help others															
6. Work in groups															
7. Lead in groups															
8. Share ideas															

INTERPERSONAL SKILLS contd **NAMES OF STUDENTS**

KEY 0 No evidence of the skill 1 Is beginning to use the skill 2 Has good use of the skill 3 Can teach someone else the skill															
9. Organize group activities															
10. Behave politely															
11. Teach others															
12.															
13.															
14.															
15.															
16.															

MOTIVATIONAL SKILLS

NAMES OF STUDENTS

KEY 0 No evidence of the skill 1 Is beginning to use the skill 2 Has good use of the skill 3 Can teach someone else the skill															
1. Plan for doing my homework															
2. Do my homework															
3. Turn in my homework															
4. Organize my work															
5. Do the best I can															
6. Make things independently															
7. Think about ideas on my own															
8. Plan things on my own															

MOTIVATIONAL SKILLS contd

NAMES OF STUDENTS

KEY 0 No evidence of the skill 1 Is beginning to use the skill 2 Has good use of the skill 3 Can teach someone else the skill															
9. Try to connect ideas															
10. Strive to do better															
11.															
12.															
13.															
14.															
15.															
16.															

DASH

Name________________________

Date________________________

STUDENT PAGE 5.1.9
DASH FIFTH GRADE CONCEPT AND SKILL INVENTORY

CONCEPTS

There are four responses to each of the following entries:

0 I have no understanding of the concept.
1 I am beginning to understand the concept.
2 I have good understanding of the concept.
3 I can teach someone else to understand the concept.

Circle the ONE response that best describes where you are in your understanding of the following concepts.

	UNDERSTANDING			
CONCEPTS	No	Beginning	Good	Teach
1. Cloud types	0	1	2	3
2. Weather maps	0	1	2	3
3. Weather fronts	0	1	2	3
4. Wind chill	0	1	2	3
5. Heat Index	0	1	2	3
6. Gnomon	0	1	2	3
7. Ecliptic	0	1	2	3
8. Celestial equator	0	1	2	3
9. Constellation	0	1	2	3

Name________________________________

CONCEPTS contd	UNDERSTANDING No	 Beginning	 Good	 Teach
10. Longitude	0	1	2	3
11. Latitude	0	1	2	3
12. Right ascension	0	1	2	3
13. Declination	0	1	2	3
14. Greenwich	0	1	2	3
15. Fulcrum	0	1	2	3
16. Resistance	0	1	2	3
17. Effort	0	1	2	3
18. Wheel-and-axle	0	1	2	3
19. Inclined plane	0	1	2	3
20. Block-and-tackle	0	1	2	3
21. Force	0	1	2	3
22. Food Pyramid system	0	1	2	3
23. RDAs	0	1	2	3
24. Nutrient	0	1	2	3
25. Male urogenital system	0	1	2	3
26. Female urogenital system	0	1	2	3
27. Ovum and sperm	0	1	2	3

Name______________________________

		UNDERSTANDING		
CONCEPTS contd	No	Beginning	Good	Teach
28. Cells	0	1	2	3
29. Embryology	0	1	2	3
30. Sexually transmitted disease	0	1	2	3
31. HIV/AIDS	0	1	2	3
32. Addiction	0	1	2	3
33. Alcohol Blood Level	0	1	2	3
34. Energy	0	1	2	3
35. Muscle system	0	1	2	3
36. Skeletal system	0	1	2	3
37. Eye	0	1	2	3
38. Ear	0	1	2	3
39. Sound	0	1	2	3
40. Erosion	0	1	2	3
41. Tap and fibrous roots	0	1	2	3
42. Trees and shrubs	0	1	2	3
43. Volume	0	1	2	3
44. Mass	0	1	2	3
45. Light	0	1	2	3
46. Magnification	0	1	2	3

SP 5.1.9–4

Name______________________________

	UNDERSTANDING			
CONCEPTS contd	No	Beginning	Good	Teach
47. Annual/perennial plants	0	1	2	3
48. Metric system	0	1	2	3
49. Technology	0	1	2	3
50. Science	0	1	2	3
51.	0	1	2	3
52.	0	1	2	3
53.	0	1	2	3
54.	0	1	2	3
55.	0	1	2	3
56.	0	1	2	3
57.	0	1	2	3
58.	0	1	2	3
59.	0	1	2	3
60.	0	1	2	3

Name________________________________

SKILLS

MECHANICAL/INTELLECTUAL SKILLS

There are four possible responses to each of the following entries:

0 I have no use of the skill.
1 I am beginning to use the skill.
2 I have good use of the skill.
3 I can teach someone else the skill.

Circle ONE response.

	PERFORMANCE			
MECHANICAL/ INTELLECTUAL SKILLS	No	Beginning	Good	Teach
1. Diagram devices to show structure	0	1	2	3
2. Make a balance Use a balance	0	1	2	3
3. Make a metric rule Use a metric rule	0	1	2	3
4. Make a graduate Use a graduate	0	1	2	3
5. Use a Planetarium in mapping the sky	0	1	2	3
6. Make a telescope Use a telescope	0	1	2	3
7. Make a microscope Use a microscope	0	1	2	3
8. Identify local birds	0	1	2	3
9. Identify local trees	0	1	2	3
10. Determine the height of trees	0	1	2	3
11. Design and set up a controlled experiment	0	1	2	3
12. Consider proper number of organisms used in experiments	0	1	2	3

Name________________________________

	PERFORMANCE			
MECHANICAL/ INTELLECTUAL SKILLS contd	No	Beginning	Good	Teach
13. Solve problems by the invention of devices	0	1	2	3
14. Solve problems by invention of techniques.	0	1	2	3
15. Make a hygrometer Use a hygrometer	0	1	2	3
16. Identify different cloud types	0	1	2	3
17. Determine wind chill	0	1	2	3
18. Determine heat index	0	1	2	3
19. Use latitude and longitude in map reading	0	1	2	3
20. Make weather predictions	0	1	2	3
21.	0	1	2	3
22.	0	1	2	3
23.	0	1	2	3
24.	0	1	2	3
25.	0	1	2	3
26.	0	1	2	3
27.	0	1	2	3
28.	0	1	2	3
29.	0	1	2	3
30.	0	1	2	3

Name________________________________

INTERPERSONAL SKILLS:

There are four possible responses to each of the following entries:

0 I have no use of the skill.
1 I am beginning to use the skill.
2 I have good use of the skill.
3 I can teach someone else the skill.

Circle ONE response.

	PERFORMANCE			
INTERPERSONAL SKILLS	No	Beginning	Good	Teach
1. Carry out responsibilities	0	1	2	3
2. Share things	0	1	2	3
3. Wait turns	0	1	2	3
4. Have patience with others	0	1	2	3
5. Help others	0	1	2	3
6. Work in groups	0	1	2	3
7. Lead in groups	0	1	2	3
8. Share ideas	0	1	2	3
9. Organize group activities	0	1	2	3
10. Behave politely	0	1	2	3
11. Teach others	0	1	2	3
12.	0	1	2	3

Name________________________________

MOTIVATIONAL SKILLS

There are four possible responses to each of the following entries:

0 I have no use of the skill.
1 I am beginning to use the skill.
2 I have good use of the skill.
3 I can teach someone else the skill.

Circle ONE response.

	PERFORMANCE			
PERSONAL MOTIVATIONAL SKILLS	No	Beginning	Good	Teach
1. Plan for doing my homework	0	1	2	3
2. Do my homework	0	1	2	3
3. Turn in my homework	0	1	2	3
4. Organize my work	0	1	2	3
5. Do the best I can	0	1	2	3
6. Make things Independently	0	1	2	3
7. Think about ideas on my own	0	1	2	3
8. Plan things on my own	0	1	2	3
9. Try to connect ideas.	0	1	2	3
10. Strive to do better	0	1	2	3

DASH

Name______________________________

Date______________________________

STUDENT PAGE 5.1.2 RESPONSIBILITY

My responsibilities are listed below.

	DATE	
RESPONSIBILITY	STARTING	ENDING

DASH

Name____________________________

Date____________________________

STUDENT PAGE 5.1.3 LIBRARY CHECK-OUT

1. Record your personal research question.

2. Report your findings in answering your research question.

DASH

Name________________________

Date_________________________

STUDENT PAGE 5.1.4 LIBRARY CHECK-IN

SCIENCE RECORD BOOK
TABLE OF CONTENTS

DASH

Name__________________________

Date___________________________

STUDENT PAGE 5.1.5 WORKING TOGETHER

1. Describe how your group organized to carry out the assigned task. List the number of people needed and what each would do.

2. Compose aphorisms to guide making products for someone else to use.

3. Compose aphorisms for working with other people.

Name____________________________

Date____________________________

STUDENT PAGE 5.1.6
THINGS I CAN DO FOR MYSELF AND OTHERS

Use the table to list your goals for helping yourself. At the end of the year, use the rating scales below to evaluate your achievement by circling the number that best describes your progress.

ABILITY

1. I cannot yet do what my goal calls for.
2. I can do what my goal calls for.
3. I can do what my goal calls for and teach it to someone else.

PRACTICE

1. I do not do what my goal calls for.
2. I sometimes do what my goal calls for.
3. I usually or always do what my goal calls for.

GOALS FOR MYSELF THIS YEAR

THINGS I WANT TO DO FOR MYSELF	ABILITY	PRACTICE
	1 2 3	1 2 3
	1 2 3	1 2 3
	1 2 3	1 2 3
	1 2 3	1 2 3
	1 2 3	1 2 3
	1 2 3	1 2 3
	1 2 3	1 2 3
	1 2 3	1 2 3
	1 2 3	1 2 3
	1 2 3	1 2 3
	1 2 3	1 2 3

Name ____________________

Use the table to list your goals for helping others. At the end of the year, use the rating scales below to evaluate your achievement by circling the number that best describes your progress.

ABILITY	PRACTICE
1. I cannot yet do what my goal calls for.	1. I do not do what my goal calls for.
2. I can do what my goal calls for.	2. I sometimes do what my goal calls for.
3. I can do what my goal calls for and teach it to someone else.	3. I usually or always do what my goal calls for.

GOALS FOR HELPING OTHERS

THINGS I WANT TO DO FOR OTHERS	ABILITY	PRACTICE
	1 2 3	1 2 3
	1 2 3	1 2 3
	1 2 3	1 2 3
	1 2 3	1 2 3
	1 2 3	1 2 3
	1 2 3	1 2 3
	1 2 3	1 2 3
	1 2 3	1 2 3
	1 2 3	1 2 3
	1 2 3	1 2 3
	1 2 3	1 2 3

DASH

Name____________________

Date ____________________

STUDENT PAGE 5.1.7 APHORISMS

Rate the aphorisms below in terms of their usefulness to you. Circle the *(U)* if the aphorism is USEFUL, the *(NU)* if the aphorism is NOT USEFUL.

1. Why should we eat right?

U	NU	Eat right, feel right, grow right.

2. What foods should we eat sparingly?

U	NU	Slow down sugar, slow down fat A dash of salt is enough of that.

3. How much water should we drink in winter? In summer?

U	NU	Six glasses in winter and eight in summer Are my body's natural plumber.

4. Why do we exercise?

U	NU	Exercise 20 minutes for strength, 30 minutes for endurance.

5. When do we put things away?

U	NU	Finished for the day? Put things away.

6. To feel great how much sleep do we need?

U	NU	Sleep for eight, Wake up feeling great.

Name________________________________

7. When does one use the toilet?

U	NU	When nature calls, Listen and go.

8. How do we keep germs out our bodies?

U	NU	Mouth in the water, Not on the fountain.

U	NU	Someone else's dishes are someone else's germs.

U	NU	Wash hands before eating or fixing a hurt, After using the toilet or working in dirt.

U	NU	Every wound requires inspection. Untreated wounds invite infection.

9. How do we take care of our teeth?

U	NU	Brush twenty times up And twenty times down, Inside, outside, all around. Floss in between To complete the routine.

10. How do we keep our skin and hair healthy?

U	NU	Healthy skin and hair are clean skin and hair.

11. How do we keep from spreading germs when we are sick?

U	NU	Don't sneeze or cough with the cover off.

U	NU	When sick, stay home. Don't let your germs roam.

Name______________________________

12. Why should we stay away from alcohol, tobacco, and drugs?

U NU A smoker's a croaker.

U NU There's no excuse for drug abuse.

U NU Alcohol makes your system stall.

13. What does one do in emergencies?

U NU Remember 911
When emergencies come.

14. What kind of clothes should we wear in winter? In summer?

U NU Dark clothes feel comfortably warm.
Light clothes feel comfortably cool.

15. What color should we wear when walking at night?

U NU Wear white at night.

16. How should we keep our work environment?

U NU A clean and safe space
Is a great workplace.

17. What do concerned and caring people do for others?

U NU Sharing with others is caring for others.

18. How do we handle responsibilities?

U NU Get the job done
Then have fun.

19. When should we help others?

U NU Lend a hand
When you can.

Name______________________________

20. How do we make friends?

U	NU	**To gain a friend, be a friend.**

21. How do we play games?

U	NU	**Play fair with others and they'll play fair with you.**

22. Why are we in school?

U	NU	**School is for today and tomorrow.**

23. How can we test what we think we know?

U	NU	**If you really know and understand, Teach and give someone else a hand.**

24. How do we treat other living things?

U	NU	**Respect all living things.**

25. How can we meet our goals in life?

U	NU	**Plan AHEAD.**

26. What do we include in a reference citation?

U	NU	**When writing a reference citation we look to see That we have a double *A* and a triple *P*. Author and Article account for double *A*. Page, Publication, and Publisher complete the display.**

Name____________________________________

27. Why do we need to conserve our resources?

U NU Waste not, want not.

U NU What we save today we have tomorrow.

U NU Conserve our precious gas and oil
And work to save our coal and soil.
When they're gone there will be no more.
Remember they're things we can't restore.

28. Why should we recycle things?

U NU There's a need to recycle the things that we use.
Wasting resources we cannot excuse.
Paper and brass,
Aluminum and glass,
Their value through recycling they never do lose.

29. Why should we look for errors in our work?

U NU Errors are common in all that we do.
Knowing we make them should sharpen our view
Of our speaking and writing and thinking too.

DASH

Name________________________

Date________________________

STUDENT PAGE 5.1.8A FRIENDS

Write a happy ending to a playlet in which your characters save their friendship.

DASH

Name______________________

Date______________________

STUDENT PAGE 5.1.8B FRIENDSHIP

Assume the role of Agnes Helpin, advice columnist, and reply to one of the letters that have appeared in her column.

- **Dear Miss Helpin,**
  I have just moved to a new neighborhood and none of the kids like me. In my old neighborhood I knew all the kids and we had lots of fun. How can I make friends?
  (signed) **LONELY**

- **Dear Miss Helpin,**
  I asked my aunt to write you because I don't write English. My question is How can I make friends? I'm in an American school and can't speak English.
  (signed) **SPEECHLESS**

- **Dear Miss Helpin,**
  My best friend has just moved away. We were always together, and now I have nobody except my little brother to talk to. What can I do?
  (signed) **LOST**

- **Dear Miss Helpin,**
  My best friend is mad at me because I don't like to party with some of the other kids. They sometimes get beer and wine, and my family doesn't think that's right. What can I do?
  (signed) **CONFUSED**

Dear ______________________

Name____________________________

Date____________________________

STUDENT PAGE 5.1.9
DASH FIFTH GRADE CONCEPT AND SKILL INVENTORY

CONCEPTS

There are four responses to each of the following entries:

0 I have no understanding of the concept.
1 I am beginning to understand the concept.
2 I have good understanding of the concept.
3 I can teach someone else to understand the concept.

Circle the ONE response that best describes where you are in your understanding of the following concepts.

	UNDERSTANDING			
CONCEPTS	No	Beginning	Good	Teach
1. Cloud types	0	1	2	3
2. Weather maps	0	1	2	3
3. Weather fronts	0	1	2	3
4. Wind chill	0	1	2	3
5. Heat Index	0	1	2	3
6. Gnomon	0	1	2	3
7. Ecliptic	0	1	2	3
8. Celestial equator	0	1	2	3
9. Constellation	0	1	2	3

Name________________________________

	UNDERSTANDING			
CONCEPTS contd	No	Beginning	Good	Teach
10. Longitude	0	1	2	3
11. Latitude	0	1	2	3
12. Right ascension	0	1	2	3
13. Declination	0	1	2	3
14. Greenwich	0	1	2	3
15. Fulcrum	0	1	2	3
16. Resistance	0	1	2	3
17. Effort	0	1	2	3
18. Wheel-and-axle	0	1	2	3
19. Inclined plane	0	1	2	3
20. Block-and-tackle	0	1	2	3
21. Force	0	1	2	3
22. Food Pyramid system	0	1	2	3
23. RDAs	0	1	2	3
24. Nutrient	0	1	2	3
25. Male urogenital system	0	1	2	3
26. Female urogenital system	0	1	2	3
27. Ovum and sperm	0	1	2	3

Name__________________________________

	UNDERSTANDING			
CONCEPTS contd	No	Beginning	Good	Teach
28. Cells	0	1	2	3
29. Embryology	0	1	2	3
30. Sexually transmitted disease	0	1	2	3
31. HIV/AIDS	0	1	2	3
32. Addiction	0	1	2	3
33. Alcohol Blood Level	0	1	2	3
34. Energy	0	1	2	3
35. Muscle system	0	1	2	3
36. Skeletal system	0	1	2	3
37. Eye	0	1	2	3
38. Ear	0	1	2	3
39. Sound	0	1	2	3
40. Erosion	0	1	2	3
41. Tap and fibrous roots	0	1	2	3
42. Trees and shrubs	0	1	2	3
43. Volume	0	1	2	3
44. Mass	0	1	2	3
45. Light	0	1	2	3
46. Magnification	0	1	2	3

Name________________________________

	UNDERSTANDING			
CONCEPTS contd	No	Beginning	Good	Teach
47. Annual/perennial plants	0	1	2	3
48. Metric system	0	1	2	3
49. Technology	0	1	2	3
50. Science	0	1	2	3
51.	0	1	2	3
52.	0	1	2	3
53.	0	1	2	3
54.	0	1	2	3
55.	0	1	2	3
56.	0	1	2	3
57.	0	1	2	3
58.	0	1	2	3
59.	0	1	2	3
60.	0	1	2	3

Name________________________________

SKILLS

MECHANICAL/INTELLECTUAL SKILLS

There are four possible responses to each of the following entries:

0 I have no use of the skill.
1 I am beginning to use the skill.
2 I have good use of the skill.
3 I can teach someone else the skill.

Circle ONE response.

	PERFORMANCE			
MECHANICAL/ INTELLECTUAL SKILLS	No	Beginning	Good	Teach
1. Diagram devices to show structure	0	1	2	3
2. Make a balance Use a balance	0	1	2	3
3. Make a metric rule Use a metric rule	0	1	2	3
4. Make a graduate Use a graduate	0	1	2	3
5. Use a Planetarium in mapping the sky	0	1	2	3
6. Make a telescope Use a telescope	0	1	2	3
7. Make a microscope Use a microscope	0	1	2	3
8. Identify local birds	0	1	2	3
9. Identify local trees	0	1	2	3
10. Determine the height of trees	0	1	2	3
11. Design and set up a controlled experiment	0	1	2	3
12. Consider proper number of organisms used in experiments	0	1	2	3

Name________________________________

MECHANICAL/ INTELLECTUAL SKILLS contd	PERFORMANCE No	Beginning	Good	Teach
13. Solve problems by the invention of devices	0	1	2	3
14. Solve problems by invention of techniques.	0	1	2	3
15. Make a hygrometer Use a hygrometer	0	1	2	3
16. Identify different cloud types	0	1	2	3
17. Determine wind chill	0	1	2	3
18. Determine heat index	0	1	2	3
19. Use latitude and longitude in map reading	0	1	2	3
20. Make weather predictions	0	1	2	3
21.	0	1	2	3
22.	0	1	2	3
23.	0	1	2	3
24.	0	1	2	3
25.	0	1	2	3
26.	0	1	2	3
27.	0	1	2	3
28.	0	1	2	3
29.	0	1	2	3
30.	0	1	2	3

Name__________________________________

INTERPERSONAL SKILLS:

There are four possible responses to each of the following entries:

0 I have no use of the skill.
1 I am beginning to use the skill.
2 I have good use of the skill.
3 I can teach someone else the skill.

Circle ONE response.

	PERFORMANCE			
INTERPERSONAL SKILLS	No	Beginning	Good	Teach
1. Carry out responsibilities	0	1	2	3
2. Share things	0	1	2	3
3. Wait turns	0	1	2	3
4. Have patience with others	0	1	2	3
5. Help others	0	1	2	3
6. Work in groups	0	1	2	3
7. Lead in groups	0	1	2	3
8. Share ideas	0	1	2	3
9. Organize group activities	0	1	2	3
10. Behave politely	0	1	2	3
11. Teach others	0	1	2	3
12.	0	1	2	3

Name______________________________

MOTIVATIONAL SKILLS

There are four possible responses to each of the following entries:

0 I have no use of the skill.
1 I am beginning to use the skill.
2 I have good use of the skill.
3 I can teach someone else the skill.

Circle ONE response.

	PERFORMANCE			
PERSONAL MOTIVATIONAL SKILLS	No	Beginning	Good	Teach
1. Plan for doing my homework	0	1	2	3
2. Do my homework	0	1	2	3
3. Turn in my homework	0	1	2	3
4. Organize my work	0	1	2	3
5. Do the best I can	0	1	2	3
6. Make things Independently	0	1	2	3
7. Think about ideas on my own	0	1	2	3
8. Plan things on my own	0	1	2	3
9. Try to connect ideas.	0	1	2	3
10. Strive to do better	0	1	2	3

DASH

GRADE FIVE
CLUSTER 2

Time, Weather, and Sky

5.2.1 Weather Station
5.2.2 Heat Index
5.2.3 Weather and Its Prediction
5.2.4 Clouds and Fronts
5.2.5 Triangles
5.2.6 Gnomon
5.2.7 Size of Earth
5.2.8 Moon Through a Telescope
5.2.9 How Big and Far Away Is the Moon?
5.2.10 Paths of Celestial Bodies
5.2.11 Models of the Solar System

ACTIVITY 5.2.1 WEATHER STATION

OBJECTIVES

The students
- Manage the setting up of a weather station.
- Invent and make measuring devices for a weather station.
- Test and use measuring devices they have made.

BACKGROUND

This activity continues the study of weather begun in kindergarten. It should be started at the first of the year along with Activity 5.1.1 THE LEARNING CALENDAR. Activities 5.10.8 MAKING A HYGROMETER, 5.2.2 HEAT INDEX, 5.2.3 WEATHER AND ITS PREDICTION, and 5.2.4 CLOUDS AND FRONTS should follow it. In DASH 5 the emphasis is on national as well as local weather. It is suggested that the fifth graders become the school's official weather experts by sharing their data with other classes.

Getting Started

In WEATHER STATION the students make instruments and set up the data collection they will need for their study. It is suggested that the students work in teams of two to four people. For those students who have worked with the DASH program for one or more years, this will involve quick assembly of familiar devices. If the class is totally new to DASH, fresh invention and discussion of the measuring devices will be needed. If the class is a mixed class, some students with DASH background and some without, it is a good idea to put students new to DASH into teams with a seasoned DASH student. Allowing the veteran students to teach others the skills needed to make and use the instruments will greatly conserve time.

Management

The activity may be handled in part by a student management team. If your students come with well-developed group skills and DASH background, this activity has the potential to start them taking over aspects of class management. A management team should include students who have previously made the DASH weather instruments. With this background they can act as advisors and keep groups on task.

Preparation

It is suggested that the students operate in teams to devise logos to simplify data recording and work out the following procedures:

- Reading the indoor and outdoor temperatures.
- Measuring wind direction. See Figures 5.2.1(1) and 5.2.1(4–6).
- Measuring wind speed. See Figure 5.2.1(7). Post the Beaufort Scale.
- Measuring rainfall or snowfall. See Figures 5.2.1(2–3).
- Measuring humidity. (Initially have the students use cobalt chloride paper. After completing Activity 5.10.8 HYGROMETER they will be able to get more precise readings.)
- Recording general weather conditions using logos and arranging to get daily national weather maps from newspapers or other sources. (Have them find a way to get two copies of each map, one for the calendar and one for a "flip book" to show the dynamics of moving fronts. The flip book will be constructed in Activity 5.2.3 WEATHER AND ITS PREDICTION. Several days' national weather maps can be photocopied on a single sheet of paper and cut out so that one copy can be pasted on the Learning Calendar and the other kept for the Weather Flip Book.)
- Calculating wind chill. See Figure 5.2.1(8). Post the Wind Chill Chart.

Making Instruments

Making and standardizing instruments can be done with the help of Figures 5.2.1(1–8). Use the construction diagrams only if needed.

Recording Data

Calendar data recording should be done in the morning and at noon if possible. Having the students work in teams helps ensure that tasks are completed. Rotating the tasks helps ensure that all students understand them and can carry them out.

Internet Weather Services

If your class has access to the Internet, regional and national weather information can be brought into the classroom hourly. The students will find, however, that weather is a local phenomenon and their school data may differ sharply from broadcast information. For this reason school data should be kept along with regional data.

STUDENT ROLES

Meteorologist
Inventor

MATERIALS

tin cans
coat hangers
pliers
metric ruler
cobalt chloride paper
thermometers
plywood or Masonite for snow gauges
plastic streamers for wind direction indicators
Beaufort Scale (Figure 5.2.1[7])
Wind Chill Chart (Figure 5.2.1[8])
Student Page 5.2.1 WEATHER STATION

PRODUCTS

Weather instruments
Completed Student Pages

PROCEDURES

1. **Review previous work done in collecting weather data and tell the students that this year they will be the school's weather experts.**

   Ask such questions as these:
   - Does knowing the outdoor temperature help us make weather predictions? (Work to the idea that when the weather changes, there is normally a change in the temperature.)
   - Does knowing the wind direction help us make weather predictions? (Work for agreement that when the weather changes, we often have a change in the wind direction.)
   - Does the measurement of wind speed help us make predictions about weather? (Work for agreement that when we have a change in weather, we often have a change in wind speed.)
   - Does the measurement of rainfall and snowfall help us make predictions about the weather? (Pursue the notion that rainfall and snowfall are the result of change in weather and that their measure is a measure of the intensity of the storms that brought them.)
   - Does the measurement of humidity help us make predictions about weather? (Explore the idea that measurement of humidity helps

us predict whether there will be dew or fog in the morning. It affects our comfort.)

- Does the calculation of wind chill help us make predictions about weather? (Explore the idea that wind chill is a measure of how much the wind will lower the temperature of our moist skin below the temperature of the air. This does not help us predict weather, but it does help us predict when to take safety measures against the cold.)

2. **Assign groups to design and make the different instruments and logos and devise the procedures needed for the weather station. Use Figures 5.2.1(1–8) if needed. A student management team can be formed to help oversee the work.**

3. **Have the management team direct the students in reporting on their work. Reports should include explanation of proposed procedures and how the instruments work. Discuss modification of procedures and instruments as needed.**

4. **Have the students decide where the instruments should be placed or used.**

   Have them consider the following:
   - Protection against vandalism.
   - Ease of access.
   - Interference from buildings, plants, or other obstructions.

5. **Have the students begin data collection and list weather recording on the Responsibility Chart.**

6. **After a week of collection, review how the recording is coming along.**

   Ask such questions as these:
   - Are we making our readings at the same time each day? Why?
   - Is the rain gauge being emptied after we read it? Why?
   - In what units of measure are we recording rain and snow depth? Why? (Rain and snow should be measured in the same units—inches or centimeters or both.)
   - Why do we need to record readings not only when it rains but also when it doesn't? (Work for agreement that it tells us that we did make measurements.)

EXTENSIONS

Have the students

- Set up instruments at home to compare readings with those made at school.
- Start posting the wind chill and set up a Wind Chill Alert for the school when needed. (Even in tropical places the wind chill can make wearing a sweater advisable at times.)

ILLUSTRATIONS

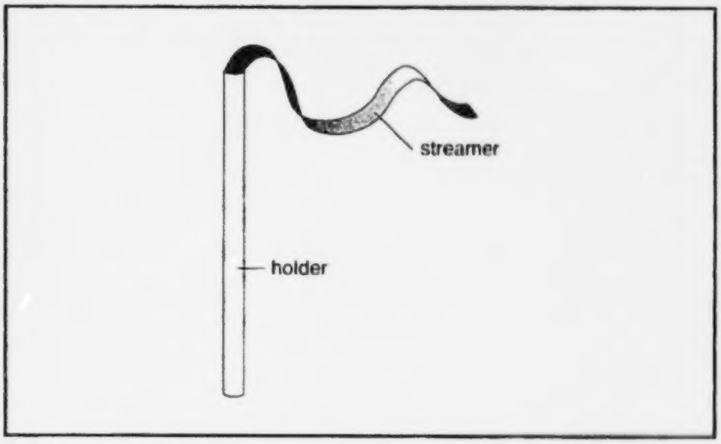


Figure 5.2.1(1) Instrument for measuring wind direction

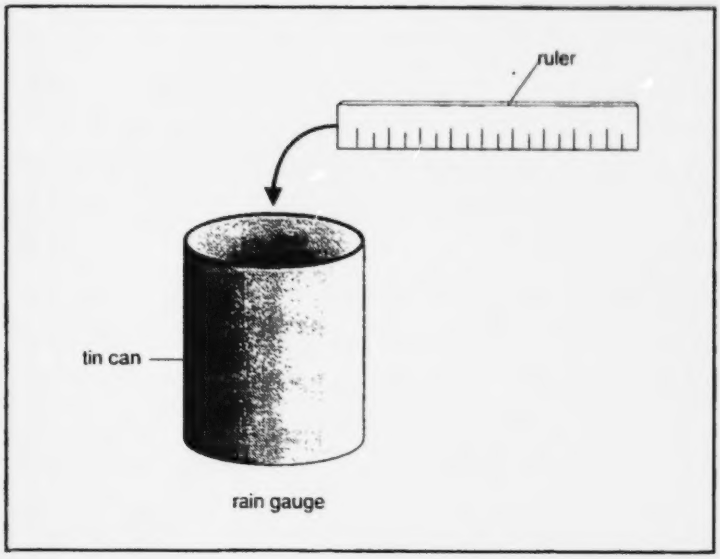
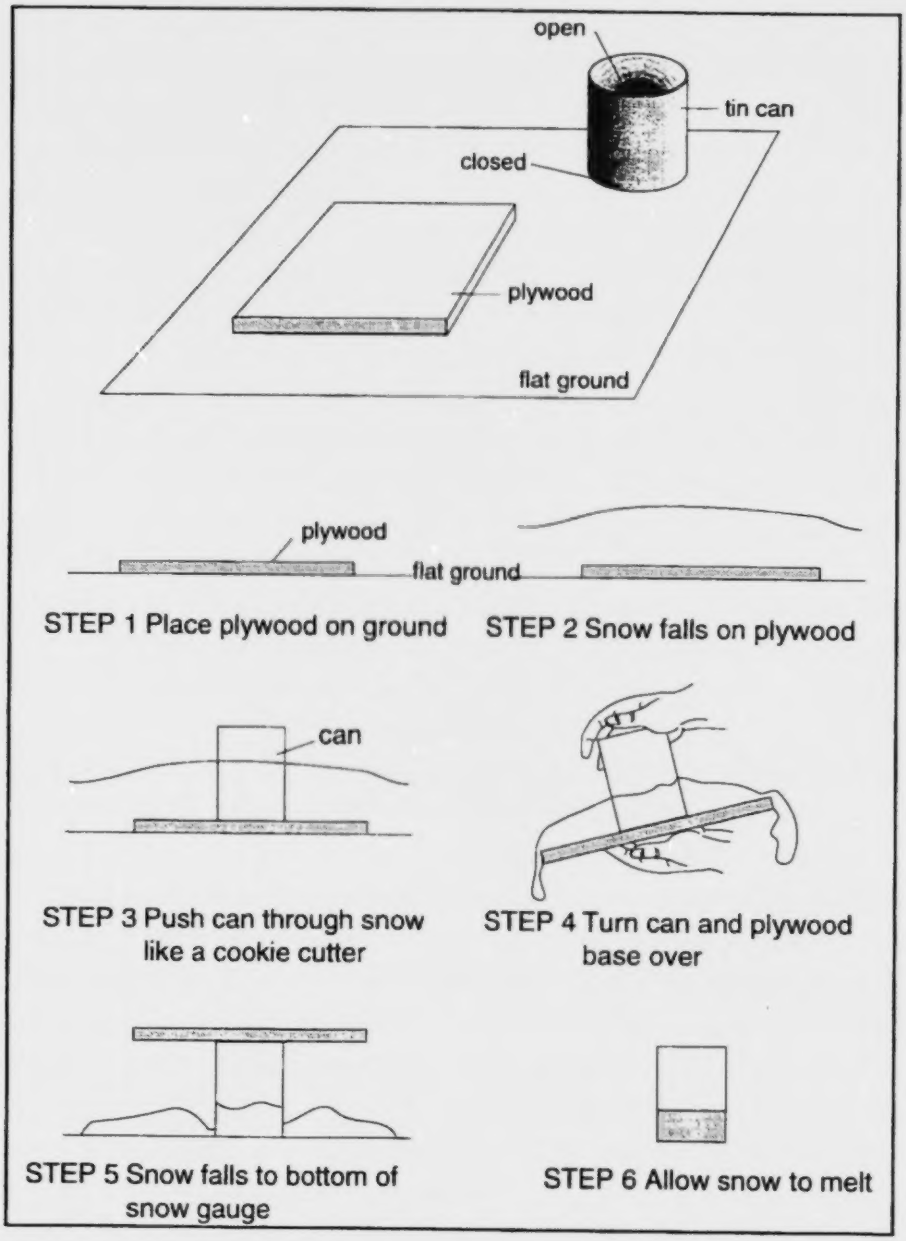


Figure 5.2.1(2) Instrument for measuring rainfall


open
tin can
closed
plywood
flat ground
plywood
flat ground
can

STEP 1 Place plywood on ground

STEP 2 Snow falls on plywood

STEP 3 Push can through snow like a cookie cutter

STEP 4 Turn can and plywood base over

STEP 5 Snow falls to bottom of snow gauge

STEP 6 Allow snow to melt

Figure 5.2.1(3) Instrument for measuring snowfall and water content

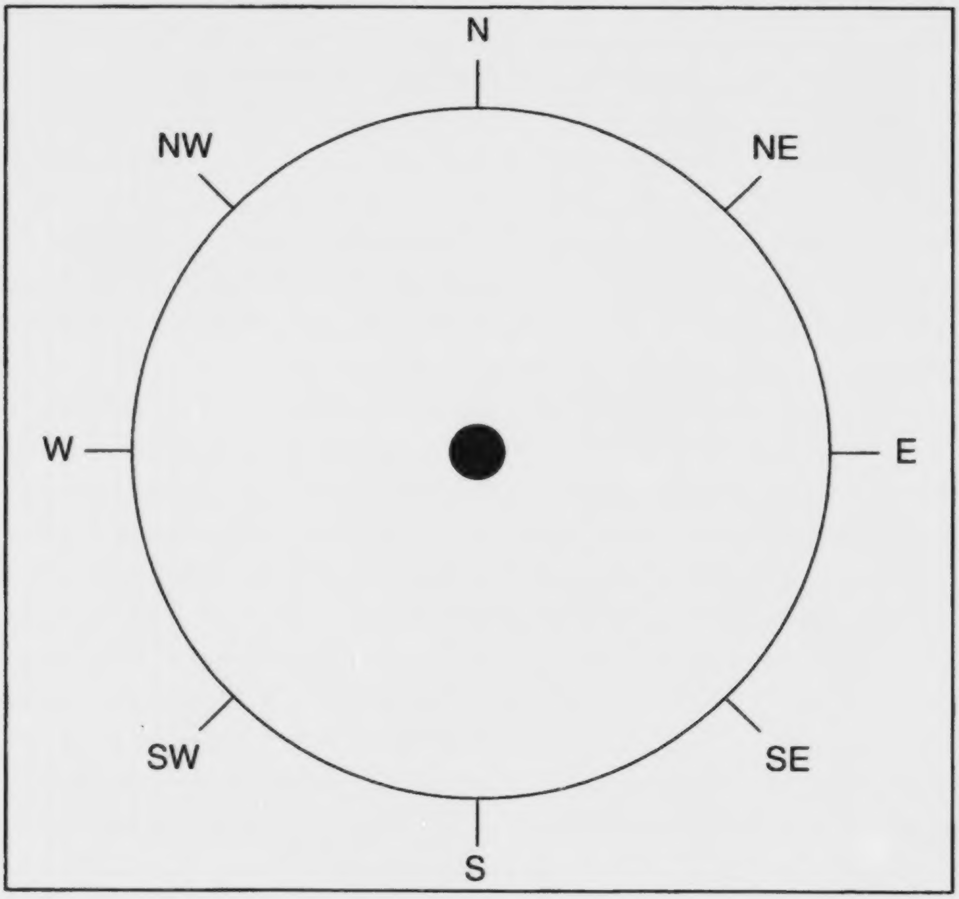

N
NW
NE
W
E
SW
SE
S

Figure 5.2.1(4) Template for a compass card

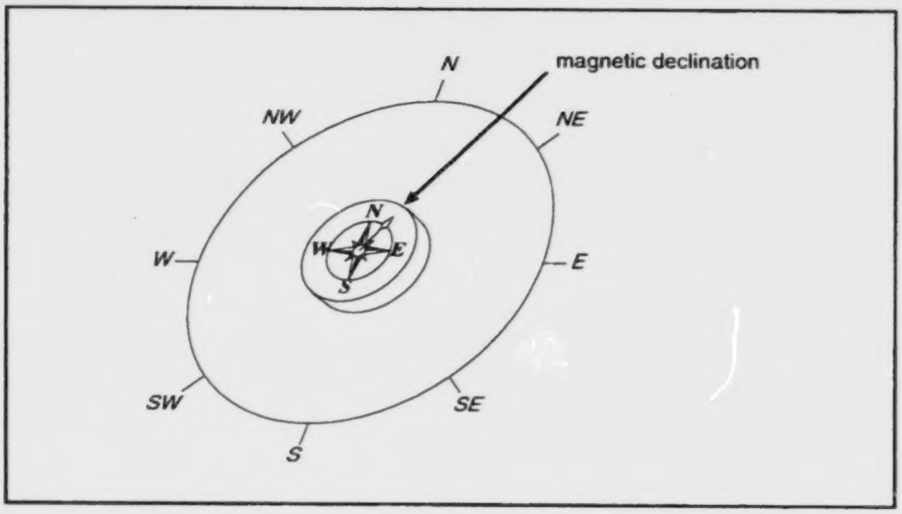

N
magnetic declination
NW
NE
W
E
SW
SE
S
N
W
E
S

Figure 5.2.1(5) Orienting a compass to account for magnetic declination, here approximately 15°. See Activity 5.2.6 GNOMON for a discussion of magnetic declination.

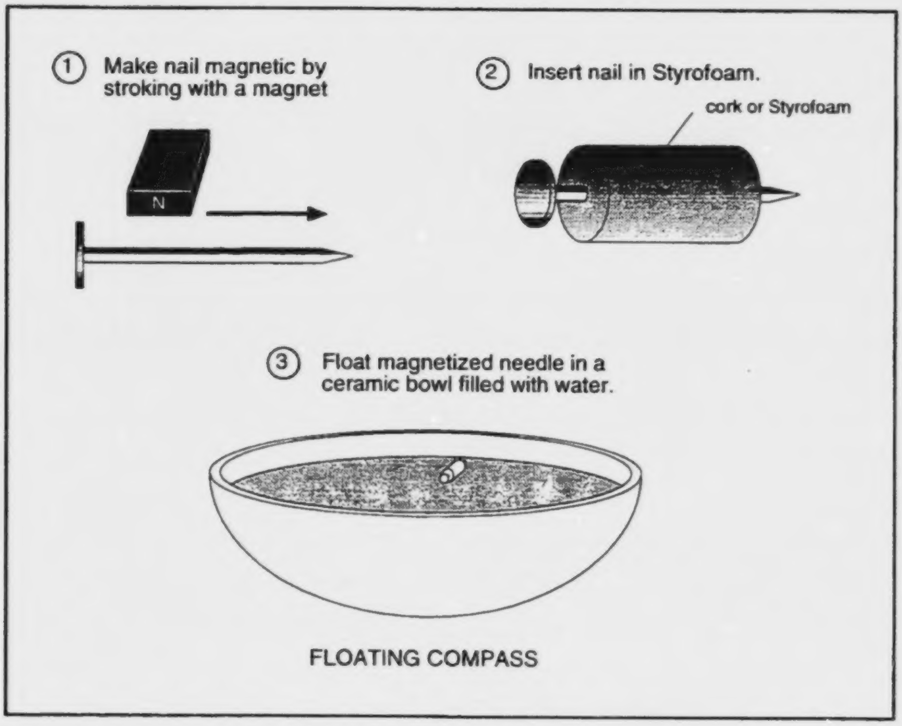

① Make nail magnetic by stroking with a magnet
N
② Insert nail in Styrofoam.
cork or Styrofoam
③ Float magnetized needle in a ceramic bowl filled with water.
FLOATING COMPASS

Figure 5.2.1(6) Method for making a floating compass

BEAUFORT SCALE

Scale No.	Miles/ hour	Km/ Hour	Indicators	Kind of Wind
0	.0 to 0.9	.0 to 1.5	Smoke goes straight up	Calm
1	1.0 to 3.9	1.6 to 6.5	Smoke drifts sideways	Light air
2	4.0 to 7.9	6.6 to 12.5	Leaves rustle	Slight breeze
3	8.0 to 12.9	12.6 to 20.5	Leaves and twigs move	Gentle breeze
4	13.0 to 18.9	20.6 to 30.5	Small branches move; dust, paper fly	Moderate breeze
5	19.0 to 24.9	30.6 to 40.5	Water ripples; small trees sway	Fresh breeze
6	25.0 to 31.9	40.6 to 51.5	Large branches move	Strong breeze
7	32.0 to 38.9	51.6 to 62.5	Trunks of trees bend; walking difficult	High wind
8	39.0 to 46.9	62.6 to 75.5	Twigs break off	Gale
9	47.0 to 54.9	75.6 to 87.5	Shingles carried away	Strong gale
10	55.0 to 63.9	87.6 to 104.5	Trees uprooted	Whole gale
11	64.0 to 72.9	104.6 to 116.5	Widespread damage	Windstorm
12	73.0 to	116.6 to	General disaster	Hurricane Tornado

Figure 5.2.1(7) Beaufort Scale

WIND CHILL CHART

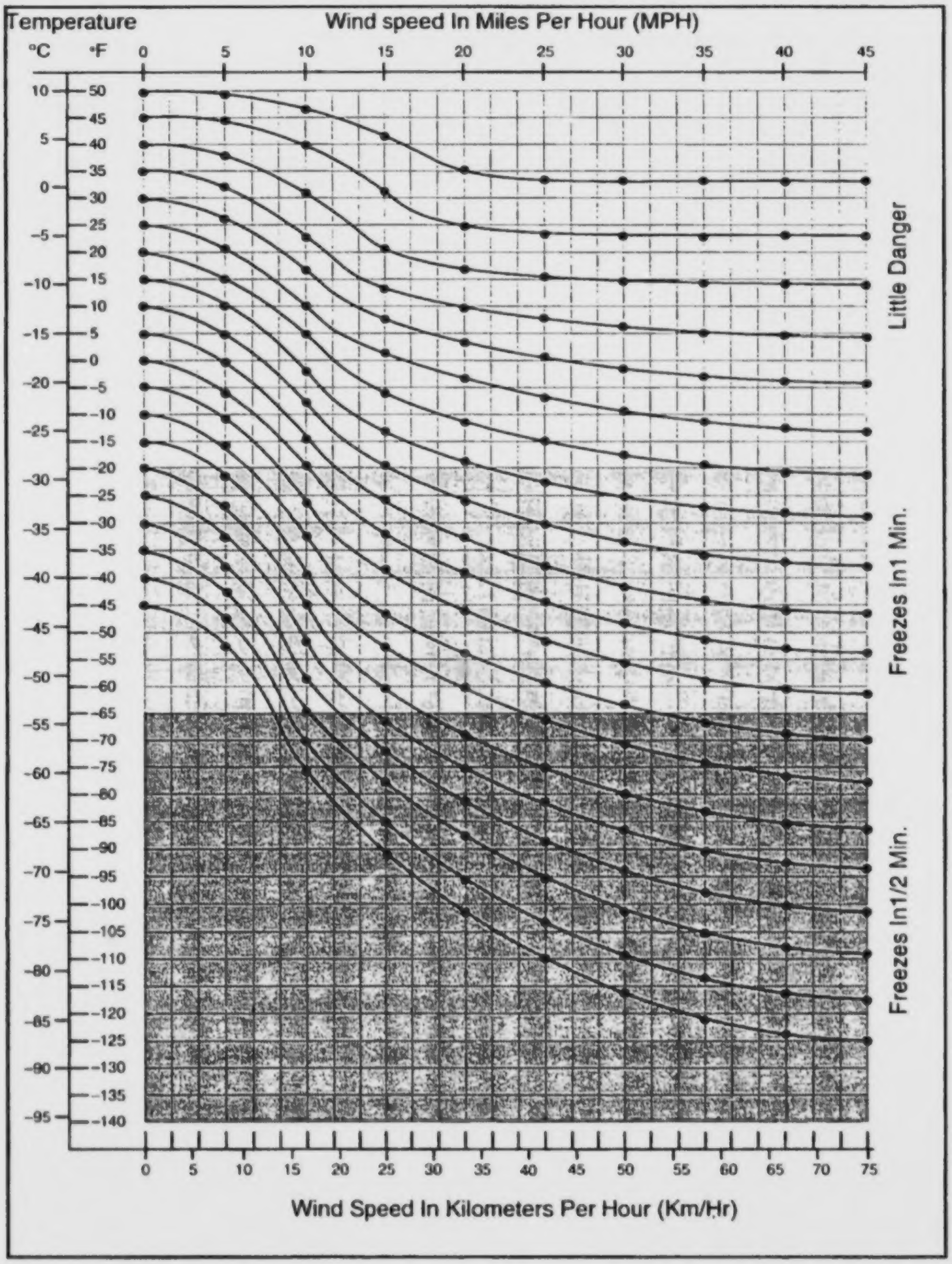


Figure 5.2.1(8) Wind Chill Chart

BEST COPY AVAILABLE

DASH

Name________________________

Date________________________

STUDENT PAGE 5.2.1 WEATHER STATION

Make diagrams of any equipment and logos you devised to carry out the procedures listed below. Describe how the equipment works.

- Reading indoor and outdoor temperatures
- Measuring wind direction
- Measuring wind speed
- Measuring rainfall or snowfall
- Measuring humidity
- Recording general weather conditions using logos
- Calculating wind chill

ACTIVITY 5.2.2 HEAT INDEX

OBJECTIVES

The students
- Use hygrometer readings to determine the heat index.

BACKGROUND

This activity should follow Activities 5.2.1 WEATHER STATION and 5.10.8 MAKING A HYGROMETER. In HEAT INDEX the students use the relative humidity indicated by their hygrometer readings to determine the heat index.

Heat Index

The *heat index* is a measure of the combined effects of humidity and air temperature on the body's ability to cool itself. The human body is cooled by evaporation of moisture in the form of sweat. When the humidity is high, less evaporation is possible, and less cooling can take place than when the humidity is low.

The heat index uses perfectly dry and motionless air (air with 0% humidity) as its standard. It tells us the temperature of air at 0% humidity that has the same effect on our body as air with a known humidity and known temperature. A heat index of 105°F refers to an equivalent dry-air temperature of 105°F. At this temperature we are in danger of heat exhaustion and heatstroke. The heat index is also expressed in Celsius units. A temperature of 105°F is equal to 42°C. See Student Page 5.2.2B HEAT INDEX CHART.

Determination of the Heat Index

To use the Heat Index Chart in Student Page 5.2.2B
- Measure the air temperature.
- Determine the relative humidity.
- Locate the air temperature in the left column and the heat index curve closest to that temperature.
- Follow the curve to the column that most closely approximates the relative humidity.
- Read the heat index in the right column across from the intersection of the curve and the relative humidity column.

With an air temperature of 105°F and a relative humidity of 50%, the heat index would be about 125°F. At this temperature there is extreme danger of heat stroke. If the temperature were 105°F and the humidity were 0%, the heat index would have dropped to 99°F, indicating that cooling can take place due to the evaporation of sweat.

Corresponding values are given for the Celsius scale. For example, at an air temperature of 40°C and a relative humidity of 50%, the heat index is about 49°C. At this temperature there is extreme danger of heat stroke.

Monitoring the Heat Index

It is suggested that the fifth grade class be made responsible for reporting to the office potentially dangerous days when the temperature and the humidity are high and the students should not exercise outdoors.

STUDENT ROLES

Meteorologist
Public health safety officer

MATERIALS

Student Pages	5.2.2A HEAT INDEX 5.2.2B HEAT INDEX CHART

PRODUCTS

Completed Student Pages.

PROCEDURES

1. Introduce the concept of the heat index.

Ask such questions as these:

- Has anyone known people who have suffered heat stroke or heat exhaustion?
- Can you describe the condition of heat exhaustion? (Work for the idea that a person who has been in the sun or in a hot room may feel weak. The skin can get cold and clammy, and the person may faint. The body temperature remains near normal.)
- Does anyone know what is happening in the body? (Work to the idea that the blood is going to the surface of the body to cool the system, and the brain may momentarily be deprived of blood.)
- What can be done for a person showing such symptoms? (Get at

the idea that people suffering from heat exhaustion should be taken to a cool place where they can lie down and put their legs up. Medical help should be obtained as soon as possible because the condition can be life-threatening.)
- What is heat stroke? (Get at the notion that *heat stroke* is a very dangerous condition in which the body temperature goes very high, often 105°F [40.5°C] or even higher. The skin is dry and the person is very flushed, often unconscious.)
- What is happening in the body? (The body can get hot enough to start destroying its own tissue.)
- What can be done for such a person? (Work to the idea of getting a person into a cold bath [often ice is needed] until the temperature comes down. A doctor should be called immediately.)
- How do we know when we are in danger because of the heat? (Get at the idea of using the heat index to predict potentially dangerous conditions.)

2. Introduce the heat index.

Have the students use the Heat Index Chart in Student Page 5.2.2B.
- Go over measurements that must be made to determine the heat index. (Relative humidity and air temperature must be measured.)
- Explain what the heat index measures. (Note that it tells us the temperature of air with 0% humidity that would have the same effect on our bodies as the air we have around us.)
- Explain how the Heat Index Chart is used.
- Have the students start to record the heat index on the Learning Calendar.
- Note that at low relative humidities the heat index temperature is less than the air temperature. (For example, at 90°F air temperature and 10% relative humidity the heat index is about 84°F. In dry deserts a 90°F temperature is quite pleasant.)

3. Set up a High Heat Index Alert System for the school.

Have the class
- Report to the office when their heat index determination shows potential danger for people who overexercise.

EXTENSION

- Have the students research how the U.S. National Weather Service reports the heat index.

DASH

Name________________________

Date_________________________

STUDENT PAGE 5.2.2A HEAT INDEX

1. Explain what is meant by the heat index.

2. Describe the symptoms of people suffering from heat exhaustion and heat stroke.

3. Describe what should be done for people suffering from heat exhaustion and heat stroke.

DRSH

SP 5.2.2B HEAT INDEX CHART

Name ______________________

Date ______________________

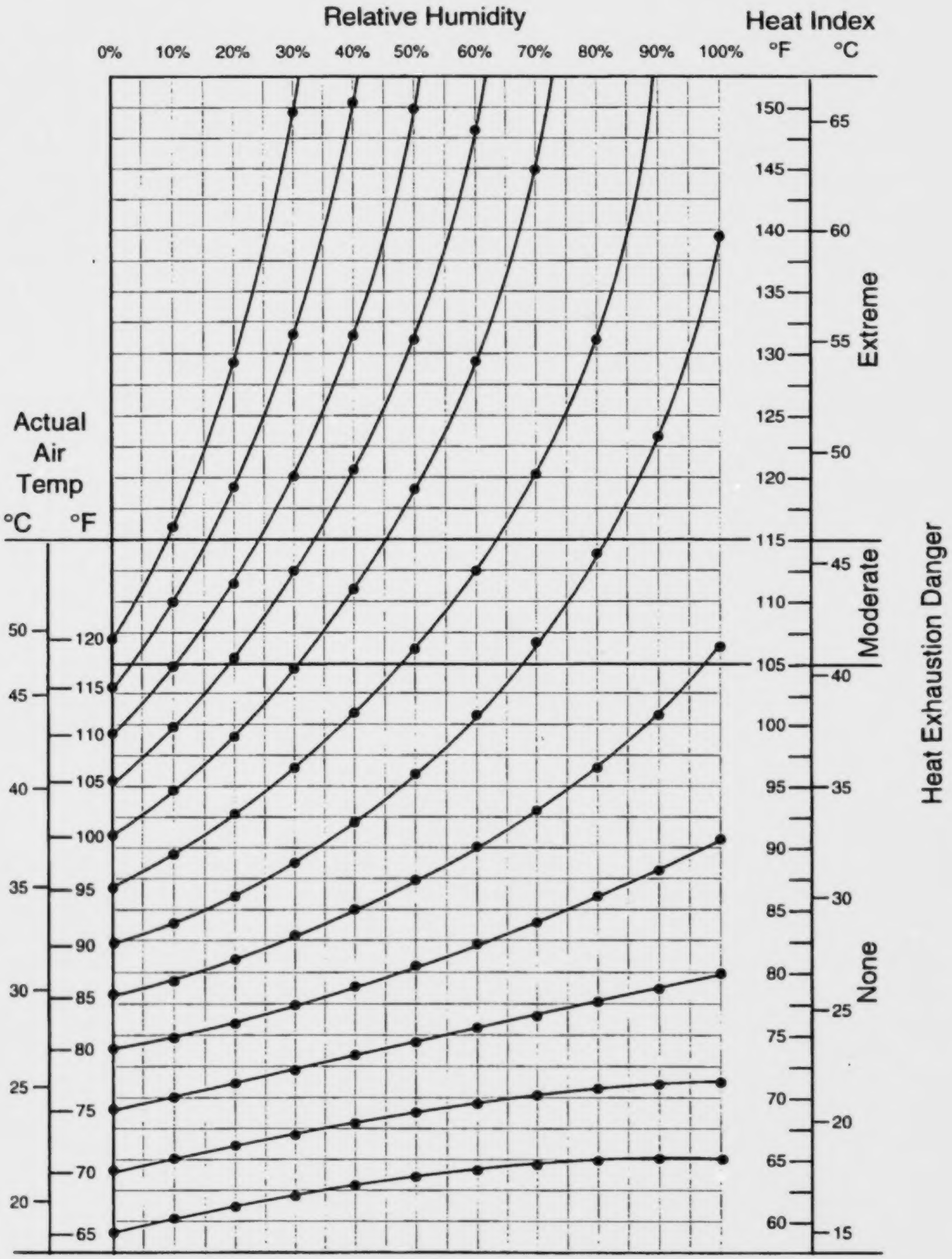


Figure SP 5.2.2B Heat index chart

ACTIVITY 5.2.3
WEATHER AND ITS PREDICTION

OBJECTIVES

The students

- Use newspaper weather maps to follow the passage of fronts across the continental United States and the Pacific Ocean.
- Predict the location and patterns of weather fronts.

BACKGROUND

This activity should follow Activities 5.2.1 WEATHER STATION and 5.10.9 MAKING A BAROMETER and be done concurrently with 5.2.4 CLOUDS AND FRONTS. The study of weather is a long-term project in which the students follow national and Pacific-wide weather patterns and make predictions about daily patterns.

Timing

This activity should be undertaken after four to five weeks of collecting weather maps and looking for patterns. Have the students work in groups to begin the prediction process and to form generalizations about changing weather patterns. They will find that there is a general west-to-east movement of weather across the continental United States and northeast-to-southwest movement across the Hawaiian Islands. They will also find that high-pressure areas usually follow low-pressure areas. Further generalizations are developed in Activity 5.2.4 CLOUDS AND FRONTS.

Support Materials

If you have access to a computer service, you should be able to get regularly updated weather information from every major city in the United States and some cities overseas. Many DASH classes can be contacted by computer and will be happy to exchange weather information.

STUDENT ROLE

Meteorologist

MATERIALS

3 x 5-in cards for Weather Flip Books
weather maps from daily newspapers
Student Page 5.2.3 WEATHER AND ITS PREDICTION

PRODUCTS

Weather Flip Books
Completed Student Pages

PROCEDURES

1. **Have the students make a concept map of their current understanding of weather.**

   Help them include such things as these:
   - Atmospheric events.
   - Types of precipitation.
   - Types of clouds.
   - Types of fronts.
   - Wind and direction.
   - Maps.
   - Predictions.
   - Temperature.
   - Humidity.
   - Heat index.
   - Wind chill.

2. **Have the students trace the movement of changing weather on their weather maps.**

   Help them carry out the following steps:
   - Trace the outline of a newspaper map. (The map can be placed under the student page and traced. For greater clarity, have the students trace against a window.)
   - Trace the progress of fronts on the outline map.
   - Find the middle of warm and cold fronts and draw arrows to show their path across the Pacific Ocean, Canada, the continental United States, Mexico, and the Atlantic Ocean.
   - Follow the path of highs and lows across the country or Pacific and connect them with arrows to show their movement over a week.

3. **Have the students mount national and local weather maps on file cards and order the cards by date to make a "flip book." Have them observe the changing patterns of weather that emerge as they flip the pages.**

4. **Help the students analyze what is reported on newspaper weather maps.**

Ask such questions as these:

- What things are recorded on the maps? (Different maps will have different information—newspaper maps usually include such things as cold and warm fronts, precipitation, temperatures, high- and low-pressure areas, and wind direction.)
- What do we mean by a front? (Get at the idea that locally a *front* is a change from hotter to colder or colder to hotter condition and often is associated with rain or snow. On a national scale, *a front* is a band-like region along which weather is changing.)
- What do darts on weather fronts refer to? (Work for agreement that they indicate a cold front and that they point in the direction the front is moving.)
- What do half circles on weather fronts refer to? (Work for agreement that they indicate a warm front and that they point in the direction that the front is moving.)
- If high- and low-air pressure data appear on the map, what is meant by high and low pressure? (Work to the idea that high pressure is a pushing down of air and low pressure is a rising of air. In ACTIVITY 5.10.9 MAKING A BAROMETER the students construct a tin-can barometer and collect barometric pressure data. High pressure as measured on the barometer will be recorded when the diaphragm is pushed *in*. Low pressure will be registered when the diaphragm pushes *out*.)
- What happens as high- and low-pressure areas move? (Work for such ideas as high-pressure areas are often associated with fair weather; lows, with storms. On maps, the winds shown around highs generally go clockwise while those around lows go counterclockwise.)
- How do these things change from day to day? (Have the students look at a succession of maps and note how each of the things they have identified on the map changes from day to day.)
- What is the direction of movement? (Note that there are two general patterns of movement—one across the United States from west to east; the other out of the Gulf of Mexico, up the

Mississippi valley, and then on to the East Coast and the Atlantic Ocean.)

5. **Alert students using any computer interschool weather services to advantages and problems.**

   Help the students note such things as these:
   - Errors in incoming data. (These can often be detected by comparing with newspaper data.)
   - Errors in their own input.
   - Advantages of regular updates.
   - Advantages of wide coverage.

6. **Have the students predict where the next day's fronts will be and what will happen to the highs and lows.**

   Ask such questions as these:
   - Who was just about correct in making their prediction?
   - How did you make your prediction?
   - What factors must we take into account to make reasonable predictions about national weather patterns?

7. **Add predictions as part of the Weather Watch on the Learning Calendar. Periodically have the students summarize their successes and reflect on the questions asked in Procedure 4.**

EXTENSION

- Have the students keep their own weather predictions to see whether they are better than those made by the class.

DASH

Name_________________________

Date__________________________

STUDENT PAGE 5.2.3 WEATHER AND ITS PREDICTION

1. Trace a weather map on the space below and follow the movement of weather patterns from the last week across it.

2. List the things that seem to determine the movement of weather patterns.

____

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____

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Name ____________________

Rules of Thumb for Predicting Weather over the Continental United States

A STORM MAY BE COMING

1. There is a ring around the moon.
2. Cumulus clouds begin to change to cumulonimbus clouds.
3. High cirrus clouds are followed by thickening stratus clouds.
4. The western sky is dark and stormy.
5. The barometer steadily drops. The possibility of a storm increases when a drop in the barometer is accompanied by conditions 1 though 4.
6. A wind from the north changes to one from the south.

WEATHER IS CLEARING

1. Barometer readings begin to rise.
2. Winds start to come from the west.

WEATHER WILL REMAIN CLEAR

1. The sky is clear or there are numerous cumulus clouds.
2. The wind comes from the west or from the northwest.
3. The barometer stays steady.

ACTIVITY 5.2.4 CLOUDS AND FRONTS

OBJECTIVES

The students
- Observe, describe, and identify clouds associated with passing fronts.

BACKGROUND

Weather is a basic topic throughout DASH. This activity should follow Activity 5.2.3 WEATHER AND ITS PREDICTION. In CLOUDS AND FRONTS the students use their predictions from Activity 5.2.3 about the passing of fronts as they observe the sequence in which clouds appear. CLOUDS AND FRONTS provides an opportunity to refine understanding of clouds.

Cloud Types

Knowing the names of clouds helps in thinking about them. At the beginning of the eighteen hundreds, the Englishman Luke Howard identified two basic groups of clouds—those that are *heaped,* called *cumulus clouds,* and those that are *layered,* called *stratus clouds.* Since then two more categories of clouds have been added—the *combination clouds* with characteristics of both heaped and layered clouds and the *precipitating clouds,* which produce rain, hail, and snow. See Figures 5.2.4(1–2).

In classifying clouds we need to know their altitude. *Low clouds* are those whose tops are found between ground level and 3 km (2 miles), *middle clouds* are those with tops between 3 km and 7 km (2 and 4-1/2) miles, and *high clouds* are those with tops above 7 km. See Table 5.2.4.

Table 5.2.4 Types of clouds

ALTITUDE	**CLOUD TYPE**			
	LAYERED	HEAPED	COMBINATION	PRECIPITATING
HIGH Tops above 7 km	Cirrostratus	Cumulonimbus* (non-precipitating)	Cirrocumulus	Cumulonimbus* Cirrus
MIDDLE Tops between 3 km and 7 km	Altostratus	Swelling cumulus*	Altocumulus (non-precipitating)	Altocumulus
LOW Tops below 3 km	Stratus Fog	Cumulus	Stratocumulus	Nimbostratus

* All these clouds except cumulonimbus and swelling cumulus are found within the altitude range shown. Cumulonimbus clouds have their bases below 3 km and their tops above 7 km.

Fronts and the Passing Sequence of Weather Events

The following kinds of generalizations will emerge with time because weather over the continental United States follows fairly consistent patterns:

- *Fronts* are places where warm and cold air masses come together.
- Fronts usually move across the continental United States from west to east or out of the Gulf moving toward the northeast.
- Fronts in Hawai'i usually move across the islands from northeast to southwest.
- Storm activity will be found along the fronts or places where warm and cold air masses come together.
- When a cold-air mass overtakes a warm-air mass (a cold front), we usually first observe an increase in the wind speed. Shortly *nimbostratus* or *cumulonimbus* clouds appear on the horizon. Because the cold front hugs the ground, low-level rain or snow clouds often appear. Cold air chills the moisture-laden warm air. When differences in temperature are great, storms along such fronts can be violent. See Figure 5.2.4(3).
- Cold fronts often pass rapidly. The passing of a cold front is usually indicated by a lowering of the temperature, a reduction of the wind speed, and a change in wind direction. Weather that follows is very often clear.
- When a warm-air mass overtakes a cold-air mass (a warm front) the first observed change will usually be high-level (above 7 km), wispy *cirrus* clouds. These are followed by *cirrostratus* clouds. Because warm air is less dense and more moisture-laden than cold air, it will ride above the cold-air mass. As the front progresses, the warm air pushes lower into the middle altitude range (3–7 km) and *altostratus* clouds form. As warm air pushes into the lower range (below 3 km), *nimbostratus* clouds are likely to form, bringing precipitation. When the front has passed, the temperature rises, and the warm air mass brings *cumulus* clouds.
- Often the air along both cold and warm fronts will have little moisture content, and no precipitation will result. See Figure 5.2.4(4).
- For various reasons, either warm or cold fronts can become stationary, and the weather may remain unchanged for a week or more.

Resources.

Post Figures 5.2.4(1–4). There are numerous books on weather that students may want to refer to. The Golden Guide series and various field guide series such as the Peterson Field Guides will be helpful in identifying clouds and recognizing front patterns.

STUDENT ROLE

Meteorologist

MATERIALS

Student Page 5.2.4 CLOUDS AND FRONTS

PRODUCTS

Completed Student Pages

PROCEDURES

1. **When the students have predicted that the weather pattern in the area is about to change because of an incoming front, set up a cloud watch. Have them use Figures 5.2.4(1–2) and field guides to identify the kinds of clouds they observe. Have them follow the sequence of clouds over time and report their observations on Student Page 5.2.4 CLOUDS AND FRONTS.**

2. **Help the students make generalizations about their findings.**

   Ask such questions as these:
   - What kind of front seemed to have passed according to your predictions?
   - Was there any noticeable temperature change?
   - If the front was a cold front overtaking a warm-air mass, what were the first clouds that you saw? (Usually these will be close-to-the-ground nimbostratus or stratus clouds. In fronts with big temperature differences, the first clouds to appear may have been large cumulonimbus clouds. These are often associated with violent weather.
   - What were the rest of the clouds that followed? (If the sequence of clouds that pass is normal, it will look like the sequence seen in Figure 5.2.4[3]. In the Hawaiian Islands a major front will result in a stratus covering.)
   - If the front was a warm front overtaking a cold front, what were the first clouds you saw? (Usually these will be high-level cirrus clouds.)

- What were the rest of clouds that followed? (If the sequence of clouds follows the usual pattern, they will look the clouds in Figure 5.2.4[4] and may result in rain. Often clouds in fronts do not have enough moisture to produce rain.)

3. **Have the students use their weather maps to follow fronts and make predictions about the clouds, wind, and temperatures they expect.**

EXTENSION

- Set up a board display of picture of clouds and have the students classify them. Have them use field guides and local experts as needed.

ILLUSTRATIONS

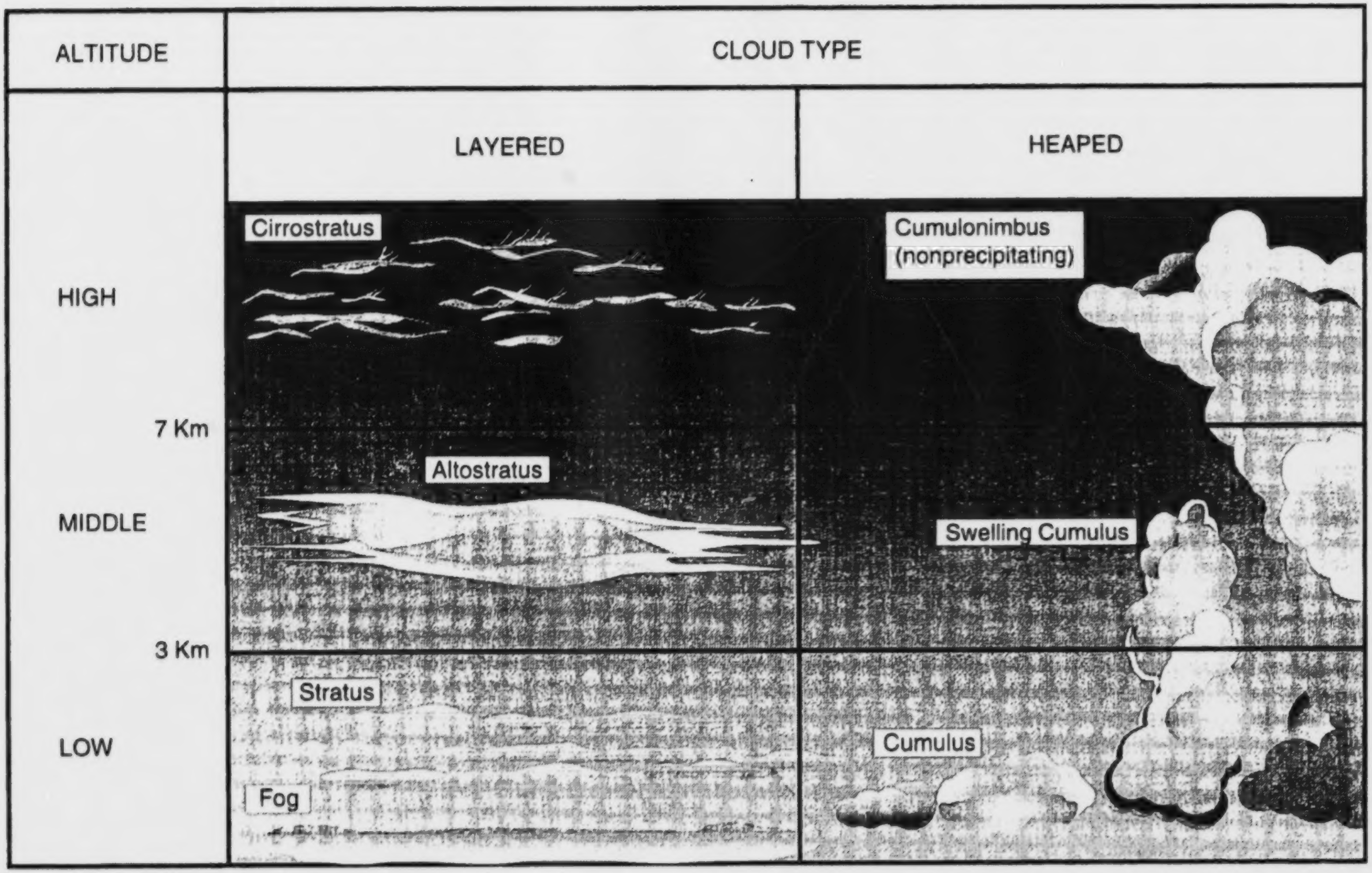
ALTITUDE
CLOUD TYPE
LAYERED
HEAPED
HIGH
7 Km
MIDDLE
3 Km
LOW
Cirrostratus
Cumulonimbus
(nonprecipitating)
Altostratus
Swelling Cumulus
Stratus
Fog
Cumulus

Figure 5.2.4(1) Layered and heaped clouds

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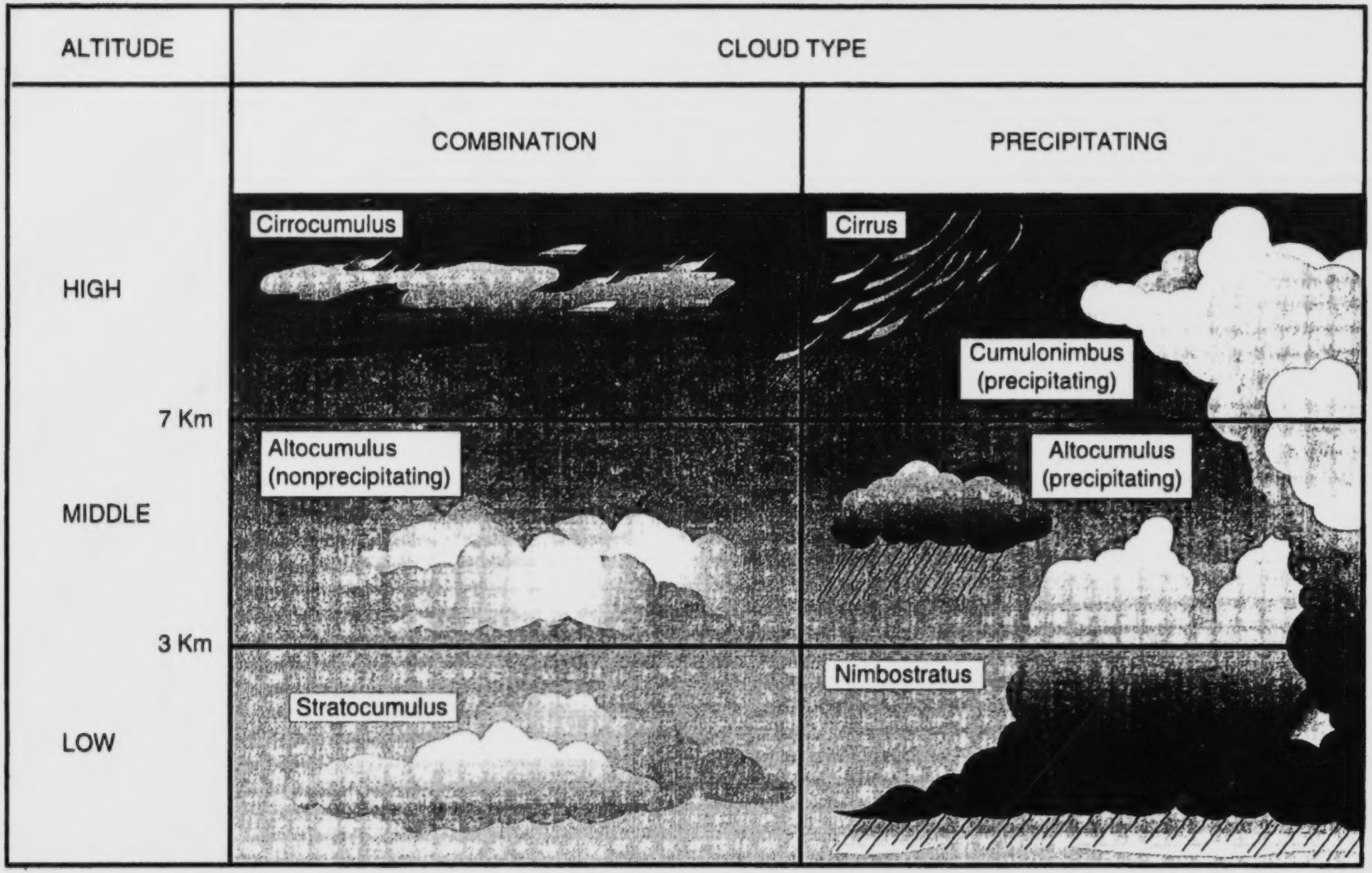
ALTITUDE
CLOUD TYPE
COMBINATION
PRECIPITATING
HIGH
7 Km
MIDDLE
3 Km
LOW
Cirrocumulus
Cirrus
Cumulonimbus (precipitating)
Altocumulus (nonprecipitating)
Altocumulus (precipitating)
Stratocumulus
Nimbostratus

Figure 5.23.4(2) Combination and precipitating clouds

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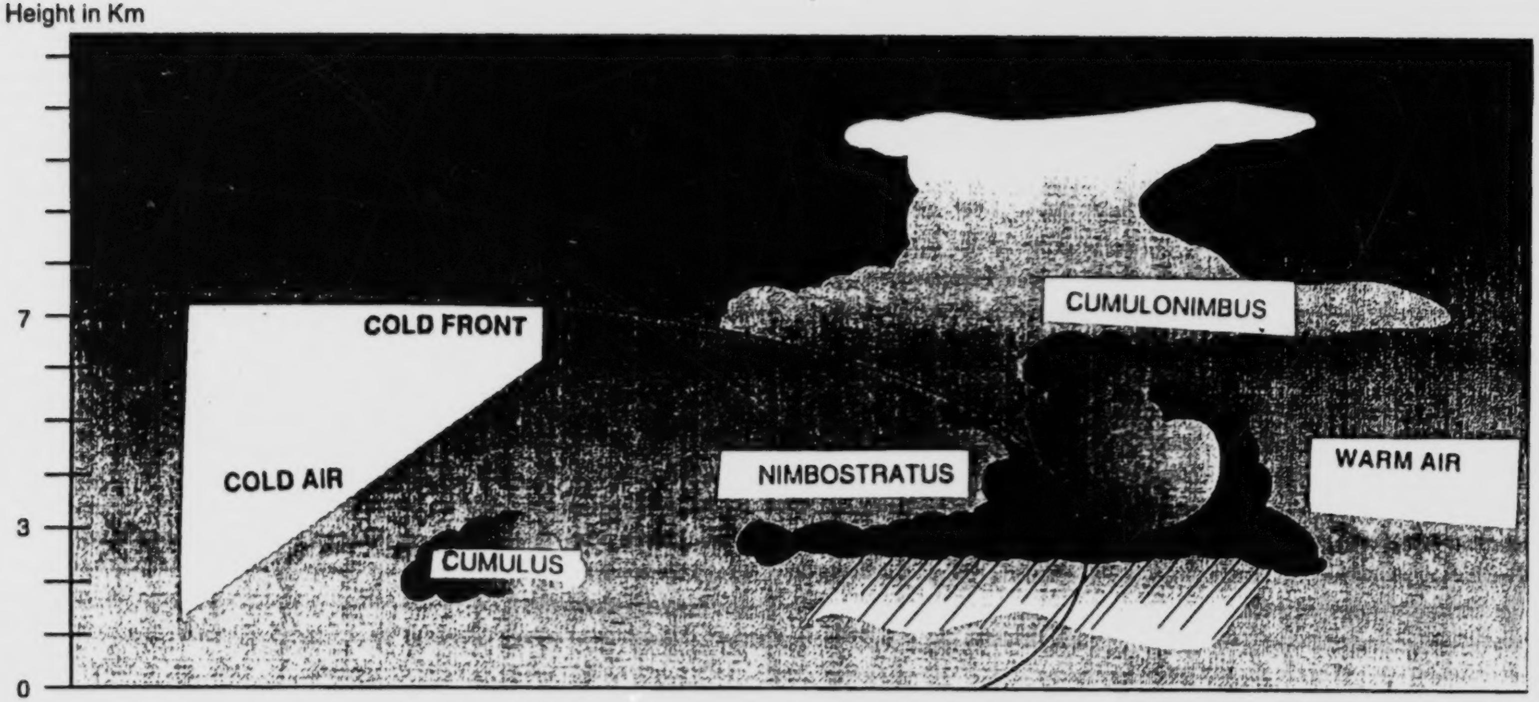
Height in Km
7
3
0
COLD FRONT
COLD AIR
CUMULUS
NIMBOSTRATUS
CUMULONIMBUS
WARM AIR

Figure 5.2.4(3) Idealized diagram showing a cold front overtaking a warm-air mass

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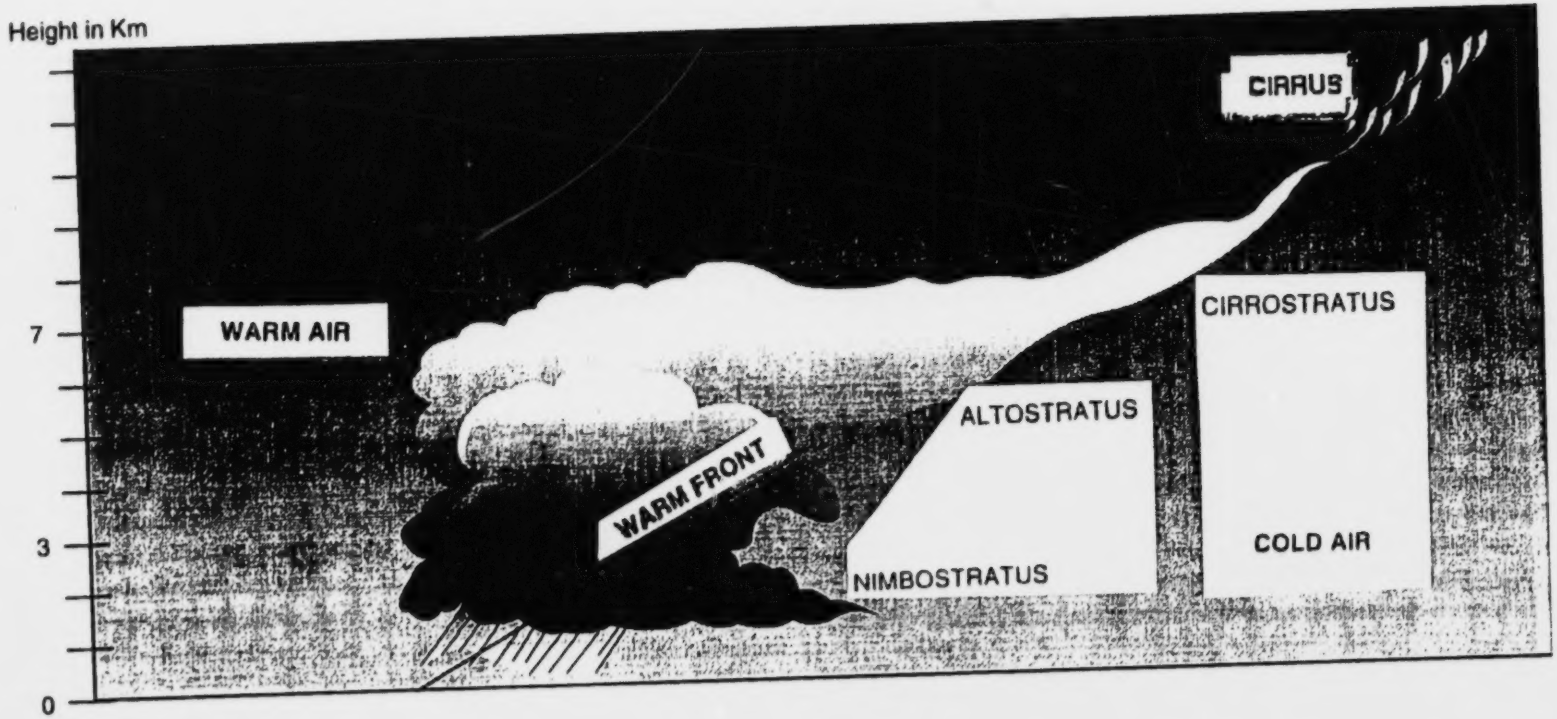
Height in Km
7
3
0
WARM AIR
CIRRUS
CIRROSTRATUS
ALTOSTRATUS
WARM FRONT
NIMBOSTRATUS
COLD AIR

Figure 5.2.4(4) Idealized diagram showing a warm front overtaking a cold-air mass

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DASH

Name____________________________

Date____________________________

STUDENT PAGE 5.2.4 CLOUDS AND FRONTS

1. Use the table below to follow the sequence of cloud types when *cold fronts* are predicted to pass through the area.

DATE/TIME	TYPE OF CLOUD	WIND DIRECTION	TEMPERATURE	BAROMETRIC PRESSURE

Name ____________________

2. Use the table below to follow the sequence of cloud types when *warm fronts* are predicted to pass through the area.

DATE/TIME	TYPE OF CLOUD	WIND DIRECTION	TEMPERATURE	BAROMETRIC PRESSURE

Name ____________________

3. How do temperature and pressure seem to be related in the passage of fronts?

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4. Describe the sequence of events in the passage of a *cold* front.

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4. Describe the sequence of events in the passage of a *warm* front.

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ACTIVITY 5.2.5 TRIANGLES

OBJECTIVES

The students
- Invent ways to compare triangles.
- Develop working definitions for similar and congruent triangles.
- Determine that the corresponding sides of similar triangles are proportionate.
- Invent a way to demonstrate that the sum of the angles of a triangle is 180°.
- Find that when a straight line cuts across parallel lines, equal angles are produced.

BACKGROUND

This activity should be carried out before Activities 5.2.9 HOW BIG AND FAR AWAY IS THE MOON? 5.4.5 MEASURING TREES, and 5.7.4 THE NORTH POLE, EQUATOR, AND ECLIPTIC. This activity is one of several that provide students with techniques to measure distances using angles. It should follow Activities 5.10.1 LINEAR MEASUREMENT, which develops the Pythagorean technique for subdividing linear distance, and 5.3.15 MUSCULAR SYSTEM, which explores techniques for making a 360° protractor.

Time Required.

This activity can be broken up and done over several days. Procedures 1 through 3 make a logical introductory grouping. Activity 5.4.5 MEASURING TREES fits well after completion of Procedures 4 and 5, and 5.2.9 HOW BIG AND FAR AWAY IS THE MOON? and 5.7.4 THE NORTH POLE, EQUATOR, AND ECLIPTIC follow smoothly after Procedures 6 and 8.

Geometry

TRIANGLES is designed to give students experience in using triangles for scaling and measurement. Here geometry is treated informally and functionally much as the students will use it throughout life.

Previous Work

Geometric concepts have been used previously in DASH. The Pythagorean technique for dividing lines in equal parts using parallel lines was introduced in DASH 4. This technique is used again in DASH 5 to divide lines in making measuring instruments such as a 360° protractor.

Congruent and Similar Triangles

The students are asked to make and manipulate two related kinds of triangles—congruent and similar. *Congruent triangles* are triangles that are identical in their dimensions. They have sides and angles that are of the same size. Congruency can be demonstrated by placing one triangle on top of another and observing that their sides and angles are equal.

Similar triangles are triangles that have angles of the same size but may have sides of different sizes. Their similarity can be demonstrated by placing one on top of another and observing the sameness of their angles. Similar triangles include all congruent triangles. However, there are many similar triangles that are not congruent.

One other feature of similar triangles is that their corresponding sides are proportionate to each other in size. For example, if one side is half as large as its corresponding or similar side, all other sides are half as large. The students use their knowledge of similar triangles to represent large triangles with smaller similar triangles.

Angles

Using a sheet of binder paper and folding techniques, the students find that the sum of the angles of triangles is 180°. They also find that a diagonal line cutting parallel lines of the binder paper produces sets of equal angles.

STUDENT ROLE

Geometer

MATERIALS

lined notebook paper
rulers
protractors
pencils
scissors
Student Pages 5.2.5 TRIANGLES

PRODUCTS

Working definitions
Completed Student Pages

PROCEDURES

1. **Tell the students that we are going to explore the secrets of triangles by folding and cutting them out of paper. We will use notebook paper to take advantage of the parallel lines. As we go along, we will use Student Page 5.2.5 TRIANGLES to keep a record of what we find.**

   Ask such questions as these:
   - How do we measure angles? (Work to the idea that we use a protractor to measure them in degrees.)
   - What is a right angle? (Work for agreement that a right angle is an angle of 90°.)
   - How many right angles do the edges of a sheet of notebook paper form? (Work for agreement that there are four.)
   - How can anyone demonstrate this? (Get a measurement of the angles.)
   - What kind of angle is made when two 90° angles are put back to back? (Work for agreement that together they make a 180° angle. Have the students place two 90° angles together. Have them look for pairs of back-to-back 90° angles—where the parallel lines of the notebook paper cut the edge of the paper, where floor tiles. come together, and so forth.)
   - What is another term for a 180° angle? (Work for agreement that it is a straight line.)
   - What do we mean when we say that the sides of notebook paper are parallel? (Work for such ideas as the sides are pairs of straight lines that are equal distances apart and if extended won't ever touch.)
   - What are other examples of parallel lines?
   - What would be working definitions of a right angle and of parallel lines? (Help the students create these definitions for the Working Dictionary.)

2. **Make two right-angle triangles by folding a piece of notebook paper diagonally from opposite corners. See Figure 5.2.5(1).**

   Have the students
   - Fold the notebook paper diagonally from one corner to the opposite corner. (Demonstrate and alert them that they need to be careful with their folding.)

- Start with one of the right angles of one of the triangles and label all the angles clockwise A–F.
- Record how they labeled triangles on Student Page 5.2.5 TRIANGLES.
- Cut the triangles apart down the diagonal line.

3. **Help the students investigate the triangles.**

   Ask such questions as these:
   - What are the things that are the same and different about the two triangles? (List the students' answers, then probe as needed about the equality of angles as follows.)
   - Are there any right angles in the triangles? Which angles are they? (Work for agreement that they are Angles A and D.)
   - Can you show that Right Angle A is equal to Right Angle D without measuring them? (Have the students explore with the paper, working to overlap one triangle on the other.)
   - Can you find any other equal angles? (List the angles they find. Angle A = Angle D, Angle B = Angle E, and Angle C = Angle F. See Figure 5.2.5[1].)
   - What is the sum of Angles B and C in degrees? (Work for agreement that together they make 90°. Put B and C back together as they were before they were cut apart.)
   - What is the sum of Angle B and Angle F? (Work toward 90°. If the students flounder, proceed.)
   - Why is the sum of Angle B and Angle F 90°? (Work for the logic that Angles B and C are equal to 90° and that Angle C is equal to Angle F. Therefore, B and F are also equal to 90°. Like things can be substituted for each other. Have the students measure or fold to show this.)
   - What is the sum of the three angles of the triangle with Angles A, B, and F? (Work for agreement that they add up to 180°.)
   - What is the sum of the three angles of the triangle with Angles C, D, and E? (Work for agreement that they add up to 180°.)

4. **Help the students investigate congruent triangles. Describe congruent triangles for the students: *Congruent triangles* are triangles that are identical; they have angles and sides that are the same. Have the students find and make congruent triangles.**

   Ask such questions as these:
   - Who can show us two congruent triangles?

- How can we test to see whether they are congruent? (Work for agreement that we put one on top of the other. See Figure 5.2.5[2].)
- How did you make the triangles? (Making the triangles will require invention. Methods could include [a] cutting the diagonal of any four-sided figure with parallel opposite sides as they did with notebook paper, [b] putting two sheets of paper one on top of the other and cutting two congruent triangles, [c] drawing and cutting two congruent triangles, or [d] other methods.)
- What can we say about the angles of these congruent triangles? (Get at such ideas as the angles in one triangle are the same as angles of the other triangle and the number of degrees in the overlapped angles are the same.)
- What can we say about the sides? (Get at such ideas as the corresponding sides of the triangles are the same lengths. *Corresponding sides* are the two shortest sides, or the two middle-sized sides, or the two longest sides of the triangles that are being compared.)
- Were the two triangles we made by folding notebook paper and cutting along the diagonal congruent? (Have the students demonstrate the triangles' congruency by laying one triangle on top of the other.)
- What would be a working definition for congruent triangles? (Have the students include their definition in the Working Dictionary.)

5. **Help the students investigate similar triangles. Describe similar triangles for the students: *Similar triangles* are triangles that when laid on top of each other have the same-sized angles; however, the sides may or may not be the same. Have the students find similar triangles and make others.**

Ask such questions as these:

- Can you make similar triangles that are not congruent triangles? (Again this will require invention. Methods could include [a] cutting one of two congruent triangles so that the sides are parallel to the original triangle, [b] drawing and cutting two triangles with the same angles but sides of different sizes, or [c] other methods.)
- How do you know that the triangles are similar? (Work for such answers as putting one angle on top of another, tracing and

comparing angles, or measuring to see whether the angles are the same.)

- Can we make smaller similar triangles by folding a larger triangle? (Help the students make smaller similar triangles by keeping the folds parallel with the existing sides. See Figure 5.2.5[3] for solutions.)
- Can we demonstrate that these smaller triangles are similar to the larger triangles? (Work for such answers as tracing and comparing or measuring to see whether the angles are the same.)
- What would be a working definition for similar triangles? (Have the students include the definition in the Working Dictionary.)

6. **Compare the sides of similar triangles. Have the students make smaller similar triangles on larger triangles by folding. See Figure 5.2.5(3).**

Ask such questions as these:

- By folding make one side of a triangle half the size of the corresponding side of the original triangle. See Figure 5.2.5(4). How do the lengths of the other two sides of the smaller triangle compare with the sides of the original triangle? (Work for agreement that they are all half as large.)
- How can we make similar triangles with one side 1/4 as large as the original? (Have the students make such triangles.)
- How do the lengths of the other two sides compare with the sides of the original triangle? (Work for agreement that they are all 1/4 as large.)
- How can we generalize this observation? (Work for something like this. Similar sides of similar triangles will all be proportionate. For example, if a triangle has a side 5 times as large as the corresponding side of a similar triangle, the other two corresponding sides will be 5 times as large as the small triangle's.)

7. **Have the students determine the sum of degrees of the angles of any triangle.**

- Can you fold a triangle with a right angle to show that the sum of the angles is 180°? (See Figure 5.2.5 [5].)
- Using a technique similar to the one used with right angles, can we find the sum of the angles of a triangle that has no right angles?

- How can we generalize this observation? (Work for something like this: The sum of the angles of a triangle is 180°. Add this statement to the Working Dictionary.)

8. **Have the students investigate the angles made by lines cutting across parallel lines. Have them draw a rectangle on paper with two sides of the rectangle made by the lines on the paper. Have them draw a diagonal from opposite corners of the rectangle. See Figure 5.2.5(6).**

   Ask such questions as these:

   - What are the things that are the same and different about the angles made by a line cutting across parallel lines? (List the students' answers, then probe as needed about the equality of angles as follows.)
   - What angles do the two vertical sides make with each of the lines that they cut across? (Work for agreement that they are all equal to 90° angles.)
   - What angles does the diagonal make with each of the parallel lines that it cuts across? (Work for agreement that the angles on the same side of the parallel lines are all equal to each other.)
   - How do we know that these angles are equal? (Have the students observe that the parallel lines have formed a set of similar triangles and the corresponding angles of similar triangles are equal.)
   - How are angles that are opposite to each other on either side of the diagonal related? (Work for agreement that they are equal.)
   - How do we know that these angles are equal? (Have the students review their diagram of the diagonal from Procedure 2. Point out that when they cut their notebook paper along the diagonal fold, Angles C and F were found to be equal. The parallel lines formed a set of similar triangles, and the corresponding angles of similar triangles are equal. The corresponding equal Angles C and F are opposite each other.)

EXTENSION

- Have the students continue to explore triangles and report on their findings.

ILLUSTRATIONS

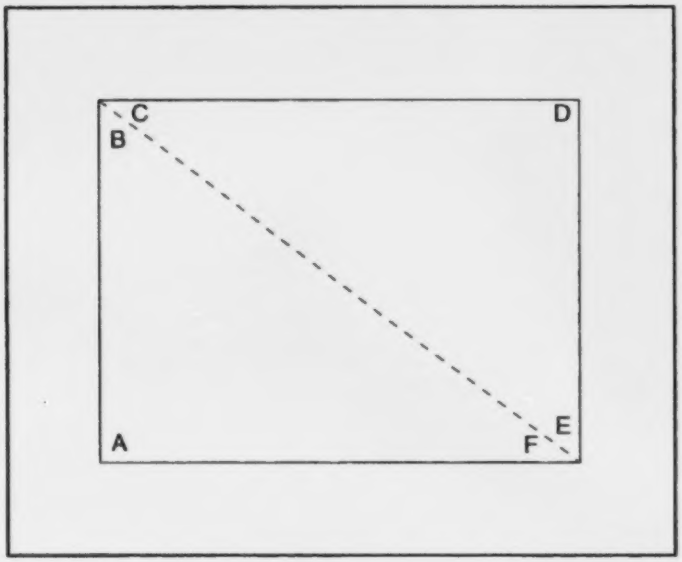


Figure 5.2.5(1) Labeled angles of triangles made by folding a piece of notebook paper diagonally (see Procedures 2 and 3)

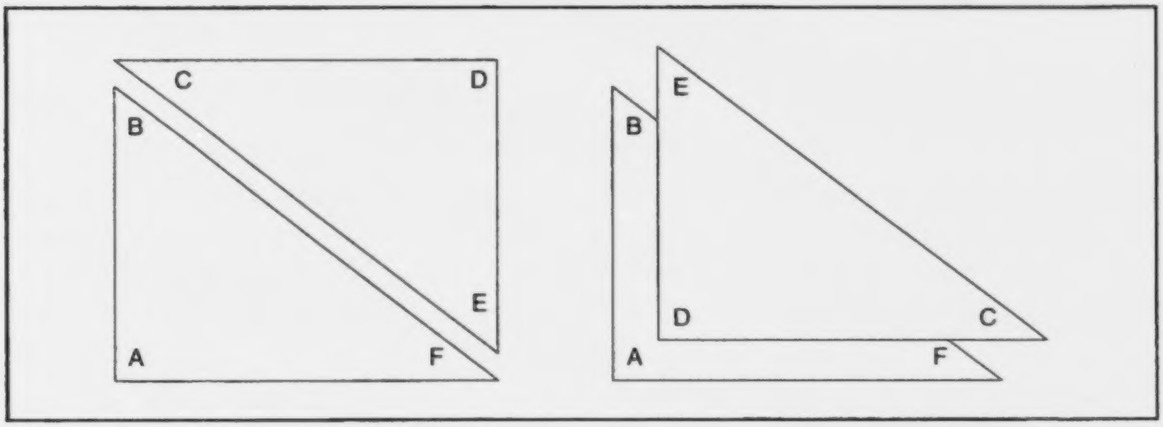


Figure 5.2.5(2) Showing congruency by overlaying triangles and that Angle B = Angle E, Angle C = Angle F, and Angle A = Angle D (see Procedure 4)

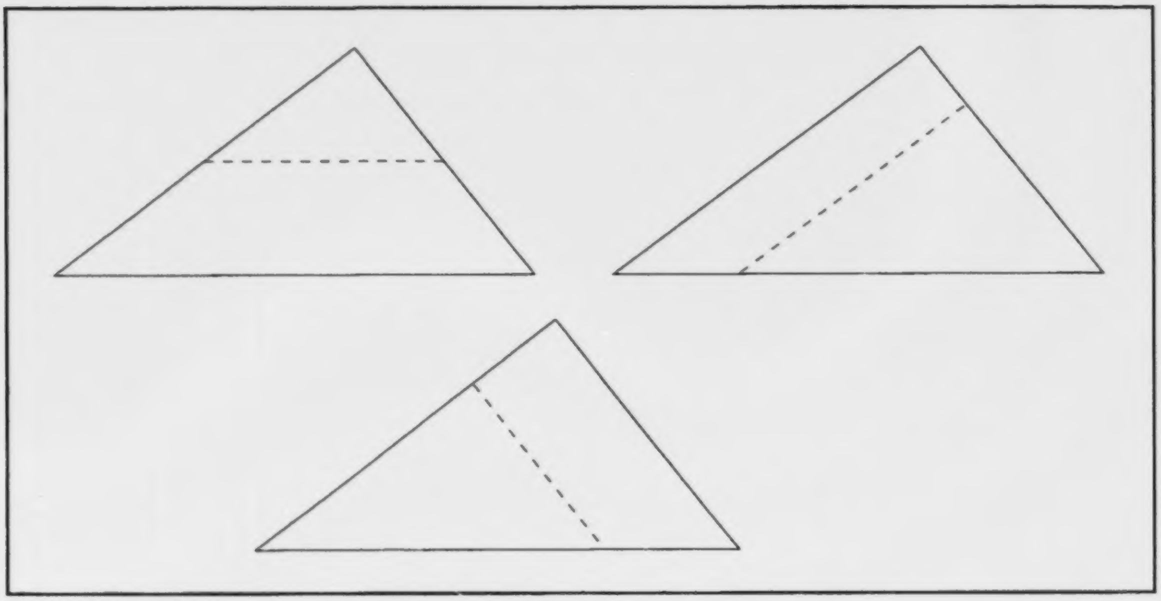


Figure 5.2.5(3) Making smaller similar triangles with a fold parallel to one side (see Procedures 5 and 6)

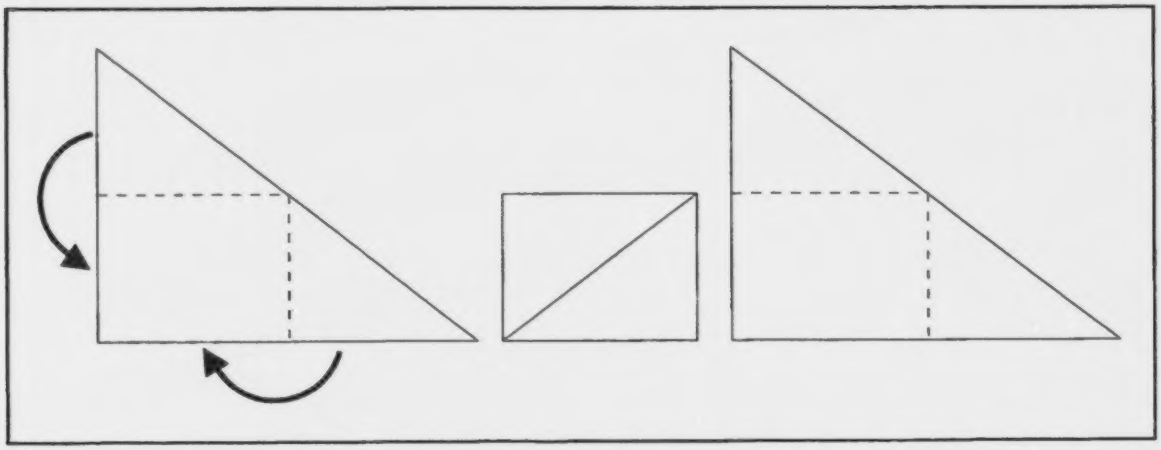


Figure 5.2.5(4) Folding to show that if the smaller of two similar triangles has one side half that of the larger triangle, all of its corresponding sides will be half as large (see Procedure 6)

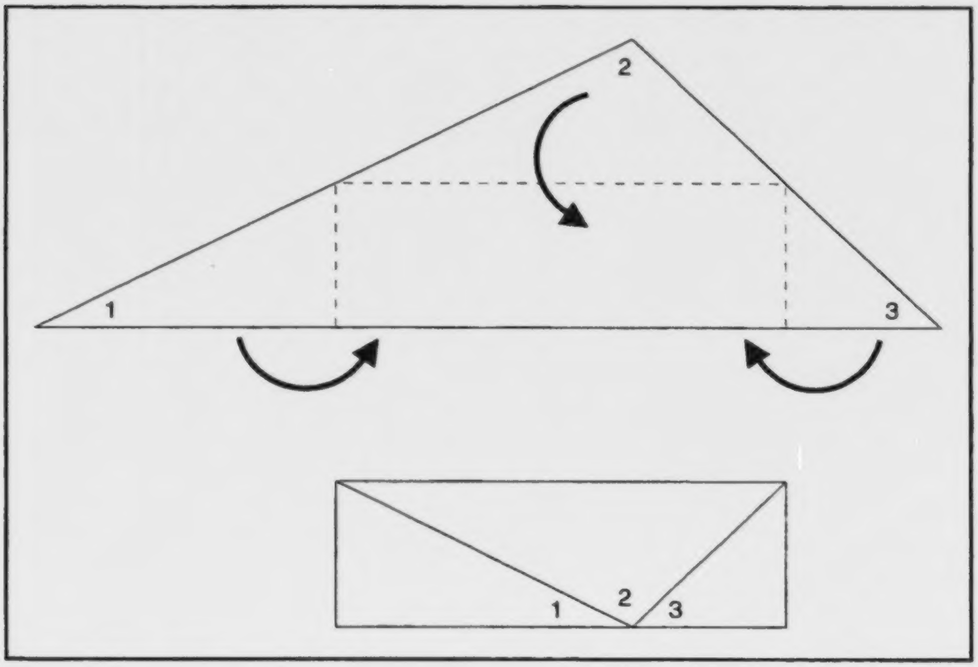


Figure 5.2.5(5) Triangle folded to show that the sum of the angles is equal to 180° (see Procedure 7)

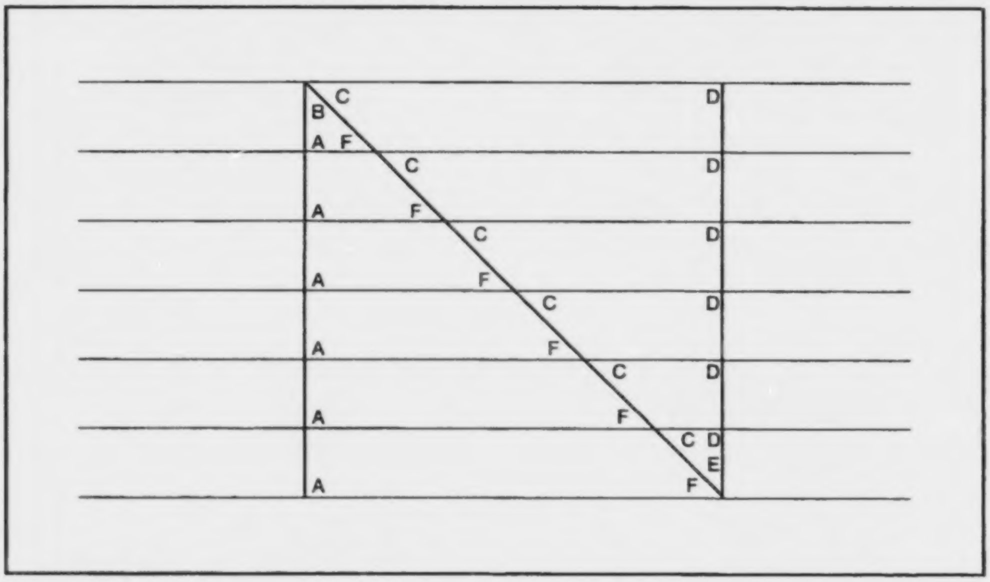

C
B
A F
C
A F
C
A F
C
A F
C
A F
C
A
F
D
D
D
D
D
C D
E

Figure 5.2.5(6) Rectangle with a diagonal drawn on lined paper showing that Angle B = Angle E, Angle C = Angle F, and Angle A = Angle D (see Procedure 8)

DASH

Name______________________

Date______________________

STUDENT PAGE 5.2.5 TRIANGLES

1. How do we measure angles?

2. What is a right angle?

3. What kind of angle is made when two 90° angles are put back to back? ________

4. What do we mean when we say that the sides of notebook paper are parallel?

5. What is your working definition of a right triangle?

6. What is your working definition of parallel lines?

Name ____________________

7. Record how you labeled the triangles made by the diagonal fold on a piece of notebook paper.

a) List the angles that are equal.

b) What is the sum of Angle B and Angle C in degrees? ________

c) What is the sum of Angle B and Angle F in degrees? ________

d) What is the sum of the angle of the triangle made by Angle A, Angle B, and Angle F? ________

e) What is the sum of the angles of the triangle made by Angle C, Angle D, and Angle E? ________

8. What are congruent triangles?

____

____

____

____

9. How can you test to see whether triangles are congruent?

____

____

____

Name ______________________________

10. What are similar triangles?

____

____

____

____

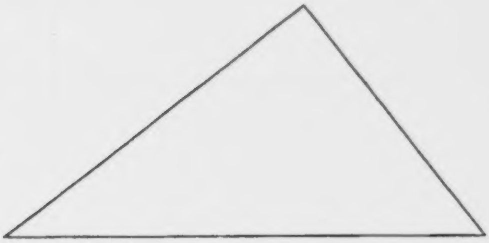
11. How can you test to see whether triangles are similar?

____

____

____

12. How did you make smaller similar triangles by making folds on a larger triangle?

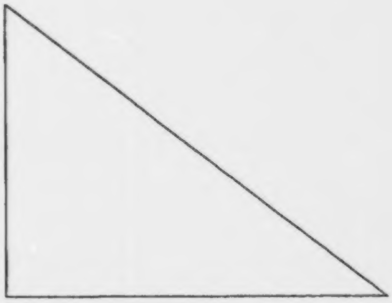


____

____

____

13. Record how you folded a triangle to show that the sum of the angles is 180°?



Name ______________________________

14. Draw a rectangle on the parallel lines below with two of its sides made by the parallel lines. Draw a diagonal from opposite corners.

15. On the rectangle with a diagonal in Item 14 label the angles of the two largest triangles (A–F). On the similar smaller triangles label the angles that correspond to Angles A–F in the same way.

16. List the angles that are equal to each other.

17. When two straight lines cross each other, what can we say about angles that are opposite each other?

ACTIVITY 5.2.6 GNOMON

OBJECTIVES

The students
- Construct a gnomon.
- Follow the sun's shadow through the fall and early spring.

BACKGROUND

In this activity the students relate records of gnomon shadows to the sun's apparent yearly north-south movement. They use their data later to trace the apparent path of the sun through the constellations on their Planetarium. This activity leads to Activities 5.7.4 THE NORTH POLE, EQUATOR, AND ECLIPTIC, 5.7.5 WHERE IS EARTH? 5.2.10 PATHS OF CELESTIAL BODIES, and 5.2.11 MODELS OF THE SOLAR SYSTEM. All the activities of the latter part of the sequence can best be done in mid-spring.

When to Start

Collection of gnomon data is best started in the first two months of the school year, though it can be postponed until the end of January.

Gnomon and Data

A gnomon can be any stick or pole that is at right angles to Earth's surface. It is used to observe the sun's shadow. The gnomon suggested for use here is a 3-to-5-in finishing nail driven into a board. The board also holds a pad of recording paper on which to mark the sun's shadow lines. See Figure 5.2.6(1). If possible, an observation site should be found that is level and can receive both morning and noon sunlight. It is best to have some sort of marking at the site so that the gnomon board can be quickly oriented the same way each time a measurement is made. A spot on a sidewalk is usually a good place. During snow periods a compass can be used to orient the board.

Ideally observations will be made at the same time, on the same day of the week, once each week. A morning reading at 9:00 A.M. and a solar-noon reading should be made. However, cloud cover may prevent the taking of morning and noon readings on the same day. This will not affect the observations. Have the students make their observations when they can. In fact, if there is a long cloudy period, a blank in the record will not affect completion of the activity.

Solar Noon

Solar noon is the moment the sun crosses the *meridian*, an imaginary circle passing from pole to pole directly over our head. At solar noon the sun is halfway in its daily east-west movement. It casts its shortest shadow, and at that moment its shadow runs directly north and south. The students are asked to find out when it is solar noon.

Using the time of north-south alignment of the gnomon shadow or the time of the shortest shadow of the day are the easiest methods to find the time of solar noon. Using either of these methods students will usually be able to find solar noon within about 7 or 8 minutes of the actual time. They can calculate the time of solar noon as the midpoint between the sunrise and sunset times listed in local newspapers if the data have been adjusted for local conditions. Phone the newspaper and ask. Almanac times will not give good data because they will not have been adjusted to the school's location.

Using a Compass

If a compass is used to find a north-south line, be sure that the students correct for magnetic declination. The map in Figure 5.2.6(2) shows isogonic lines of constant declination or deviation from true north. For example, if a school is in Los Angles, California, it has a declination of 15° east of true north. The compass would have to be adjusted so that true north is 15° west of the direction of the needle. A school in the middle of upper New York state would be located between isogonic lines 10° W and 15° W, so true north would be between 10° and 15° east of the direction of the needle. For schools between isogonic lines, either get corrections from a survey map or estimate the declination from the map in the figure.

MATERIALS

compass
gnomon board
3-to-5-in finishing nail
hammer
pad of recording paper
Student Page 5.2.6 GNOMON

PRODUCTS

Gnomon
Gnomon data
Completed Student Pages

PROCEDURES

1. **Indicate that we need a gnomon to follow the sun through the constellations. If the students have not made a gnomon before, have them use Figure 5.2.6(1) as a guide and make one. Have them use Student Page 5.2.6 GNOMON to describe their instrument.**

   Help the students
   - Make a gnomon.
   - Practice orienting the gnomon north and south.

2. **Tell the students that to determine the movement of the sun through the constellations we need to mark two shadow lines once each week—one at 0900 hours and one at solar noon. Also note that we will need to use solar noon rather than school-clock noon. Review the difference between school-clock noon and solar noon.**

   Ask such questions as these:
   - When is it noon on our clock? (Work to the idea that noon on the clock is at 1200 hours.)
   - When is it solar or sun noon? (Work to the idea that solar noon is the time when the sun is halfway in its passage across the sky and its shadow points north.)
   - How can we find when it is solar noon?

3. **Have the students divide into teams to determine how to find solar noon. Help them use their gnomon to test their method for determining solar noon. Have them report the school-clock time that corresponds to solar noon. Discuss their findings.**

   Ask such questions as these:
   - How did you make your determination?
   - What was the shadow like at solar noon compared to other times during the day? (Work for agreement that it was shorter than all the rest. If there is question, help the students continue their exploration.)
   - Where did the sun's shadow point? (Work for agreement that it pointed north.)

- How much difference was there between solar noon and school-clock noon? (This will be a variable. In some locations there may be two hours or more difference in clocks, particularly when clocks are set for daylight saving time.)
- How can we arrive at a common solar noon time? (Work toward some common technique.)
- Where will our noon measurements be over several days? (Work for agreement that if made at the solar noon, measurements will be on the same north-south line.)

4. **Help the students start their observations of the length of the gnomon-shadow line at 0900 hours and at local solar noon.**

   Have the students
   - Keep records of the gnomon-shadow-line data on a single sheet of paper up to mid-December and on a second sheet of paper after the first of the year. (Help the students label each point with a date and time of day. To be sure that the data are not lost, the record sheet can be photocopied at regular intervals.)
   - Check the record for patterns after the first month. (Up to December 22, the 0900-hour lines and the noon lines will get longer, and the angle between the noon and 0900-hour lines will get smaller. After that the shadow pattern will reverse. The lines will get shorter, and the angle between them will get progressively greater.)
   - Make adjustments for daylight-saving time changes on the 0900-hour readings.
   - Predict where the lines will be drawn over the next month.

5. **Help the students continue following the movement of the sun up to mid-December. Discuss the work.**

   Ask such questions as these:
   - How close were your predictions?
   - What do you predict will happen to the movement of the shadows when we return from vacation?
   - Why might there be a change? (Remind the students that December 22 is the time of the winter solstice, the shortest day of the year.)

6. **Again review the data several weeks after the first of the year.**

Ask such questions as these:
- How close were your predictions?
- What do you predict will happen to the movement of the shadows next month? (Continue to check the students' predictions. Continue this investigation until the students do Activity 5.7.4 THE NORTH POLE, EQUATOR, AND ECLIPTIC, which is best done in mid-spring.)

7. **After the first of the year, have the students prepare for Activity 5.7.4 THE NORTH POLE, EQUATOR, AND ECLIPTIC by determining the number of degrees the North Star is above the northern horizon.**

Have them
- Identify the star they are measuring. (The North Star [Polaris] will be the last in the handle of the Little Dipper. See the Planetarium for location. The North Star is a relatively dim star and may be difficult to see when the night air is not clear.)
- Report how they are measuring the height. (The simplest way is to use their fists. The number of fists will correspond to the latitude of the observer. Help them recall that each fist measures 10°, 2° per finger or thumb. An observer at latitude 35° N will find the star about 35° or three and a half fists above the northern horizon. This method will be sufficiently accurate for our purposes.)
- Record the height once a week on Student Page 5.2.6 GNOMON.

EXTENSION

Help the students
- Use a globe and a flashlight to explore what happens to the noon-shadow line as a gnomon is moved closer to the two poles. (The shadow will get longer.)

ILLUSTRATIONS

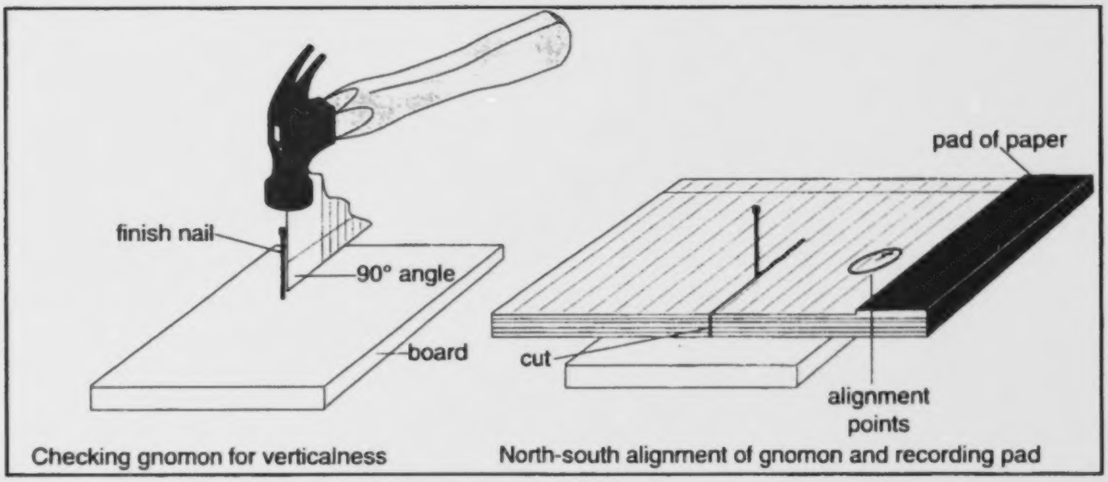

finish nail
90° angle
board
Checking gnomon for verticalness
pad of paper
cut
alignment points
North-south alignment of gnomon and recording pad

Figure 5.2.6(1) Construction and orientation of a gnomon

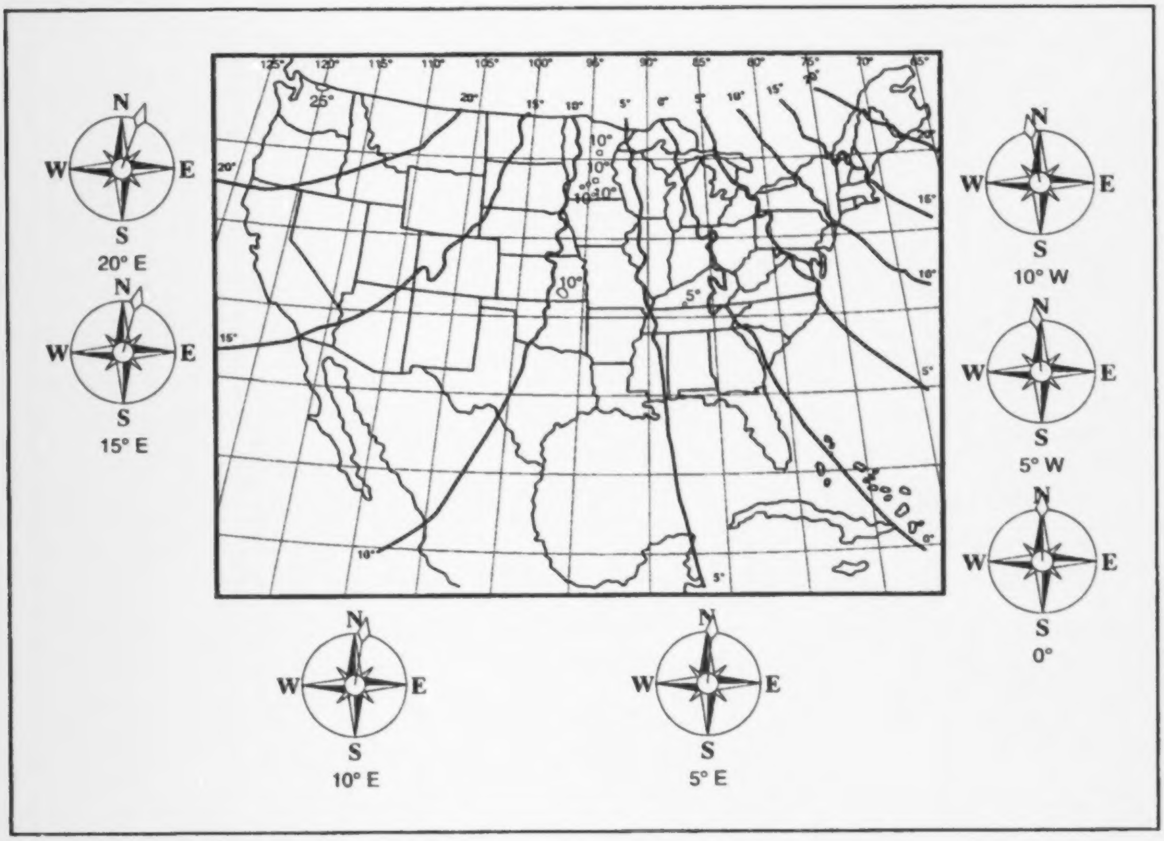

N
W
E
S
20° E
15° E
10° W
5° W
0°
10° E
5° E
125°
120°
115°
110°
105°
100°
95°
90°
85°
80°
75°
70°
65°
25°
20°
15°
10°
5°
0°

Figure 5.2.6(2) Isogonic lines of magnetic declination showing constant lines of deviation from true north in degrees. Compass readings should be adjusted as shown to give true north-south orientation. Estimate magnetic declination between isogonic lines. Along the 0° declination line magnetic declination and true north will be the same. On the 10° line to the right or east of the 0° line, a compass will read 10° West. On the 10° line to the left or west of the 0° line a compass will read 10° East. The irregularities in the declination lines seem to be due to magnetic variations in Earth's crust.

DASH

Name________________________

Date________________________

STUDENT PAGE 5.2.6 GNOMON

1. Construct a gnomon and invent a way to make sure that it always has the same orientation. Draw your gnomon and describe how you oriented it.

2. What does the gnomon-shadow line tell us about the path of the sun during the year?

____

____

____

____

____

____

____

SP 5.2.6–2

Name ______________________________

3. **In the table below, record the height of the North Star above the northern horizon.**

DATE	DEGREES		DATE	DEGREES

ACTIVITY 5.2.7 SIZE OF EARTH

OBJECTIVES

The students
- Invent a way to determine the circumference of Earth.
- Calculate the circumference of Earth.

BACKGROUND

This activity begins the search for the dimensions of celestial bodies and should follow 5.7.1 WHERE IN THE WORLD ARE WE? and 5.3.15 MUSCULAR SYSTEMS (here a 360° protractor is invented). The search is continued in Activities 5.2.9 HOW BIG AND FAR AWAY IS THE MOON? and 5.2.11 MODELS OF THE SOLAR SYSTEM. The spherical nature of the Earth was investigated in 4.2.14 FLAT OR ROUND EARTH?

Calculating Earth's Circumference

In SIZE OF EARTH the students are asked to develop their own technique to determine the circumference of Earth. Though the students will probably have some experience with globes, a review of certain ideas is usually needed.

Grappling with how to determine circumference gives the students opportunity for invention. Anytime students have problems, Socratic questions can be used to stimulate thinking or add insights. One technique for finding Earth's circumference is shown in Figure 5.2.7.

Great Circles

When we measure the circumference of Earth, we are measuring the distance around a *great circle.* The equator is one of the Earth's great circles. Meridians or lines of longitude stretching from pole to pole are halves of great circles. The other halves are on the opposite side of Earth. All great circles are on planes passing through the center of Earth.

Longitude

Longitude is a measure of distance in degrees east or west of the *prime meridian,* which is a line of longitude running north and south through Greenwich, England. A line of longitude includes all points from pole to pole that are the same number of degrees from the prime meridian. At the poles where all lines of longitude converge, the distance between them is

0. At the equator the distance between longitudinal lines that are a degree apart is about 69 miles or 111 km.

Latitude

Latitude is the distance north and south of the equator measured in degrees. One degree of latitude is also a distance of about 69 miles or 111 km. A circle or parallel of latitude includes all points that are the same distance from the equator. Circles of latitude get smaller and smaller as they approach the poles. At the poles they have 0 diameter.

Example Calculation of Circumference

An example of how the circumference of Earth can be found using a longitudinal circle will illustrate what students might do. A longitudinal circle is made up of the front and back half circles of longitude. See Figure 5.2.7. Two school sites, *(x)* and *(y)* , are found by students to be about 1,400 miles apart. Site *(x)* is 20° north of *(y)*. The students calculated that the distance around Earth on a circle of longitude is 18 times as far as from *(x)* to *(y)*. To get this, they divided the full 360° by 20° (360° ÷ 20° = 18). By multiplying 18 times the distance of 1,400 miles, they found the circumference to be about 25,200 miles. In a different situation, calculation could also be made of Earth's circumference around the equator.

Using the approximations from distance scales on globes and maps to determine Earth's circumference will give a range of 24,000–26,000 miles or about 38,400–41,600 km. The actual longitudinal measure through the poles is about 24,860 miles or 39,800 km.

STUDENT ROLES

Geometer
Navigator

MATERIALS

globes
map of the United States
compass for drawing circles
Student Page 5.2.7 SIZE OF EARTH

PRODUCTS

Completed Student Pages

PROCEDURES

1. **Introduce the problem of finding the distance around Earth. Give the students globes to inspect.**

   Ask such questions as these:
   - If Earth is round, how can we find its circumference?
   - Can you find where we live on your globe? (Have the students point to the spot.)
   - Can you find the line of longitude (the line running north and south) that is closest to our school? What is it?
   - Can you trace this line north to the pole? What happens to it? (Work for the observation that it stops and then there is a different line of longitude on the other side of the globe.)
   - As we move to the South Pole, what happens to the longitude line? (Work for the idea that again the line stops and another line of longitude on the other side of the globe begins. These two longitudinal lines on either side of the globe form a great circle. It follows that the distance around such a great circle would be the circumference of Earth.)
   - Are there other great circles? (Work to the observation that there are many joining lines of longitude and there is also the great circle of the equator.)
   - How many degrees are there in a longitudinal great circle? (Work to the idea that every full circle has 360°.)
   - How is a longitudinal great circle divided north and south? (Work for agreement that it is divided by latitude lines.)
   - How is latitude measured? (Work to the observation that it is measured in degrees north and south of the equator.)

2. **Have the students discuss and determine the distance around Earth (its circumference) along a longitudinal great circle. Have them work in small groups. Indicate that they can use students in other schools as correspondents.**

   Ask such questions as these:
   - How can we determine the circumference of Earth? (Get the students' responses and allow them to pursue their own plan. Continue with the questioning *only* if further prompting is needed.)
   - If we know how far south or north another place is from where we are, what would we need to know to find the circumference of Earth? (Work for the idea that we would need to know the

latitudes of the two positions; that is, how many degrees north south they are apart.)

- How could we find the latitude of a school? (Work for such ideas as asking the school on the Internet, finding the latitude on a map, possibly going to the school and determining the number of degrees the North Star is above the northern horizon, or determining the angle of the sun's noon shadow at the equinox.)
- How could we find how far a school is north or south of us? (Probe for such ideas as measuring the distance between latitudes on a map or finding the distance on a globe. The distance between 10° of latitude is about 69 miles or 111 km. Again have the students work in small groups to try to find the distance.)

3. Have the students demonstrate how they found Earth's circumference. Compare the answers.

EXTENSIONS

Have the students

- Calculate the diameter of Earth from its circumference. Pi (π) is 3.14.

$$\text{Circumference} = \pi \times \text{Diameter}$$
$$\text{Diameter} = \text{Circumference} \div \pi$$
$$\text{Diameter} = 24{,}860 \text{ mi} \div 3.14 = 7{,}917 \text{ mi}$$
$$\text{Diameter} = 40{,}008 \text{ km} \div 3.14 = 12{,}739 \text{ km.}$$

- Make a class table of dimensions of celestial bodies, beginning with the dimensions of Earth.

ILLUSTRATION

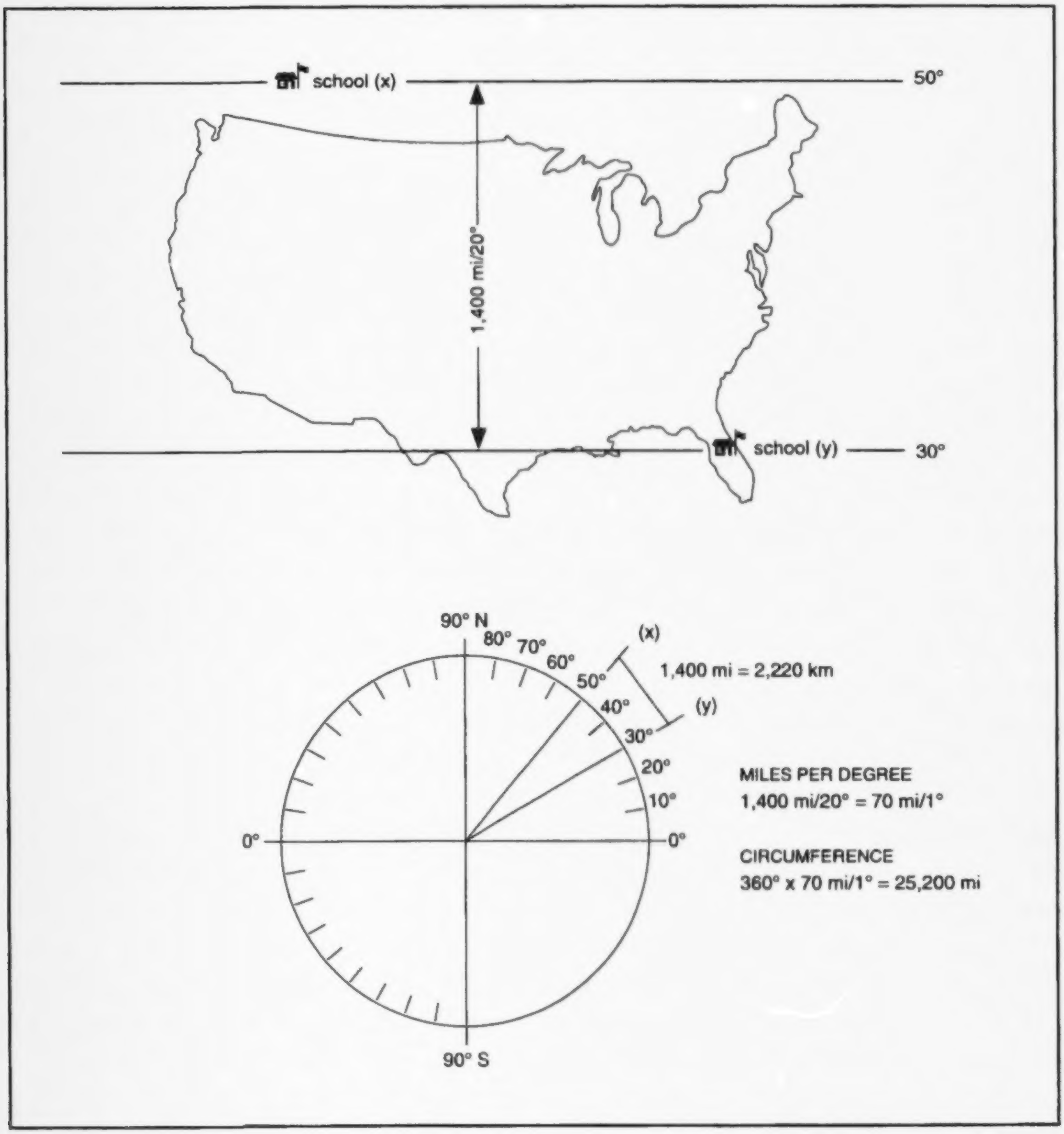

school (x)
50°
1,400 mi/20°
school (y)
30°
90° N
80°
70°
60°
50°
40°
30°
20°
10°
0°
0°
90° S
(x)
(y)
1,400 mi = 2,220 km
MILES PER DEGREE
1,400 mi/20° = 70 mi/1°
CIRCUMFERENCE
360° x 70 mi/1° = 25,200 mi

Figure 5.2.7 Calculation of the circumference of Earth. The distance between schools *(x)* and *(y)* is approximately 1,400 miles. The difference in latitude is 20°. Using these measurements, Earth's circumference is 25,200 miles.

DASH

Name________________________

Date________________________

STUDENT PAGE 5.2.7 SIZE OF EARTH

Describe how you found the circumference of Earth. Use a diagram if needed.

ACTIVITY 5.2.8 MOON THROUGH A TELESCOPE

OBJECTIVES

The students

- Use telescopes or field or opera glasses to observe the moon in the daytime and at night.
- Identify the part of the moon they are seeing.
- Observe that the same side of the moon always faces Earth.
- Determine that the moon rotates on its axis once during each of its revolutions around Earth.

BACKGROUND

This activity should be carried out after completion of Activity 5.10.5 MAKING A TELESCOPE and 5.10.6 STABILIZING THE TELESCOPE. About 30 days will be required for data collection.

Moon Observations

MOON THROUGH A TELESCOPE begins by having the students observe the moon at school in the daytime and at home at night. The activity should be started three or four days into the moon's first quarter. The home viewing should verify that the same side of the moon can be seen throughout the moon's cycle. The students should use Student Page 5.2.8 MOON THROUGH A TELESCOPE to record their observations.

Normally the students will find that the view of the moon is clearer at night. They should continue to observe the moon for a full cycle, recording in diagram form what they are observing. This part of the activity can be done by groups and the data can be shared. Again, the purpose is to see that the same side of the moon always faces Earth. See Figure SP 5.2.8(1).

Sides of the Moon

After they have observed the moon throughout its cycle, the students are asked to compare what they have observed with diagrams of different sides of the moon. It will normally be agreed that the same side faced the Earth during the entire time of their observation.

Following this first cycle the students observe the moon for a few more days to determine whether the same side of the moon continues to face Earth. They will see only the near side of the moon as shown in Figure SP 5.2.8(2). Be sure *not* to hand out the diagram until they are working on Procedure 4 and have observed a full cycle of the moon.

Moon's Rotation

Having verified that the same side always seems to face Earth, the students address the question of whether the moon turns or rotates on its axis. To answer this question, the students use Figure SP 5.2.8(3) and determine that the moon does turn on its axis once each revolution around Earth. It is important to have the students go through the exercise of placing a pencil on the diagram so that they can feel the rotation. See Figure 5.2.8.

Using the Telescope

The students can observe the moon through opera or field glasses or their telescopes from Activity 5.10.5 MAKING A TELESCOPE. As noted in Activity 5.10.6 STABILIZING THE TELESCOPE, it is necessary to rest or secure a telescope on a solid mount to keep an object as small as the moon in the field of view. Resting the scope on a sandbag or tying it to a rigid upright will help. Opera and field glasses will normally not have to be stabilized because the shortness of their lens barrels gives greater control. It is always helpful to rest the elbows on a solid surface.

Inverted Image

Call attention to the upside-down image they see of the moon when they look at it through their telescopes. This is due to the nature of the telescope, which inverts all objects. Opera and field glasses do not invert the image.

Drawings of the Moon

The students should be able to identify the open spaces on the moon called *maria*. The name comes from the Latin and means seas. When they were first viewed through a telescope, it was thought these regions might well be ancient seas. In drawing the moon the maria can be used as common markers. They will begin to appear in the crescent moon phase. Maria are found only on the *near side* of the moon.

Models of the Moon's Revolution

If the students have not had DASH 4, it is best to carry out Activity 4.2.24 MOON PHASES AND THE SUN while the class is observing the moon. This

Start-up Activity will give the students models to explain the moon's phases and its revolution about Earth.

STUDENT ROLE

Astronomer

MATERIALS

student-made telescopes or field or opera glasses
map or globe of the moon
overhead or slide projector as light source for moon-shadow model
pen or pencil with a clip
tennis or other balls for moon models
Activity 4.2.24 MOON PHASES AND THE SUN
Student Page 5.2.8 MOON THROUGH A TELESCOPE.

PRODUCTS

Moon drawings
Completed Student Pages

PROCEDURE

1. **Set the stage for the activity by having the students practice with their telescopes to view and draw the moon during the day. Start 3–4 days into the moon's first quarter or crescent stage. Have them record their work in Student Page 5.2.8 MOON THROUGH A TELESCOPE.**

   Help the students
   - Sketch as much detail of the moon's surface as they can.
   - Compare their sketches with their partners'.
   - Correct any obvious errors in observation.
   - Determine whether the moon looks the same through the telescope as it does with our naked eye. (This may take several days. The telescope inverts objects so the image of the moon they see will be upside down compared to the one seen with the naked eye or through opera or field glasses.)

2. **Have the students take their telescopes home and make a similar viewing after sunset. They may use opera or field glasses if they wish. Again have them sketch what they see. Discuss their early drawings.**

   Ask such questions as these:
   - Did we all see the same things? (Compare the drawings. There normally will be more detail in the night diagram.)
   - How do the night observations compare with the day observations? (If taken on the same day, they will include the same features, but at night those features will be seen more sharply.)
   - How do you think the moon will look one week from now?

3. **For a month have the students view the moon once or twice each quarter at home or at school and make drawings of what they see. This may be done individually or in groups. Gaps in the observations will not hurt the inquiry.**

4. **At the end of the moon cycle have the students locate the moonscape they have been observing on a moon globe or flat maps of the moon that show both sides. (See Figure SP 5.2.8[2].)**

   Ask such questions as these:
   - Can you recognize any part of the moon that we have seen on the globe or map of the moon?
   - Have we seen all of the moon over the month? (Work for agreement that they have seen only one side.)
   - What part of the moon have we seen? (Work for agreement that sketches look closest to the *near side* picture.)
   - What part of the moon do we see in the period of the first quarter? (Work for agreement that they saw only a little of the *near side.*)
   - What part of the moon do we see in the period of the second quarter? (Work for agreement that they saw more of the *near side.*)
   - What part of the moon do we see during the full moon? (Work for agreement that they saw all or most of the *near side.*)
   - What part of the moon do you predict we will see in the first quarter of the next moon cycle?
   - What part of the moon do you predict we will see in the next moon cycle when the moon is full?

5. **Help the students check their predictions during the first week or so of the next moon cycle and compare their new observations with their observations from the first period.**

Ask such questions as these:

- What part of the moon did you see during the second cycle? (Work for agreement that again they saw the *near side.)*
- What do your observations indicate about the way the moon moves around Earth? (Work to the idea that the same side of the moon always seems to face us.)
- How do you think we know what is on the other side of the moon? (This is an opportunity for students to research moon exploration or to hypothesize that unmanned space probes and the manned space explorations of the 1960s could have gathered the information.)
- Would the other side of the moon ever get any light? (This leads to our next inquiry.)

6. **Help the students work in groups to explore how the far side of the moon receives sunlight. Use balls and a flashlight or projector light as models. For classes that have not had DASH 4, have the students complete Start-up Activity 4.2.24 MOON PHASES AND THE SUN.**

Ask such questions as these:

- Looking at your model, does the other side of the moon ever get any sunlight? (Take all answers and expect contradiction.)
- Can you show us how you got your answer using your model?
- Did anyone come up with a different conclusion? (Let the students debate their answers. At all times require that they use their models to demonstrate their answers. If there is no resolution, point out that early photographs of the moon were made with light-sensitive cameras needing a surface illuminated by sunlight. Which of the models of the moon would allow such photography?)
- If the other side of the moon gets sunlight, when does it get that light? (Help the students use their models to show that some part of the far side is lighted when some part of the side toward us is dark.)
- When is the far side totally in the light? (Help the students use models to show that when the moon is new, the far side is completely lighted.)

- When is the far side totally in the dark or in night? (Help the students use models to show that when the moon on our side is full, the far side is completely dark.)
- How long is the moon day? The moon night? The moon night and day together? (Help the students show that the *moon day*, the period when any one spot on the moon is lighted by the sun, is half the moon's cycle, about 14-1/2 Earth days. The rest of the cycle, about 14-1/2 Earth days, is the *moon night*. The full night-and-day cycle is about 29 Earth days.)

7. **Help the students shade in the night side of the moon on Figure SP 5.2.8(3) which shows four positions of the moon in its revolution about Earth. Help them determine whether the moon rotates on an axis as demonstrated in Figure 5.2.8.**

Help them
- Show Earth, the moon, and the light from the sun. (See Figure 5.2.8.)
- Show the moon at its four quarter positions.
- Identify the side of the moon that faces Earth with an arrow drawn from the center of the moon to the middle of the arc facing Earth.
- Determine whether the moon rotates on its axis. (By following the path of the arrows the students should be able to see that the moon rotates once on its axis with each of its revolutions around Earth.)

EXTENSION

Help the students research the following:
- What the environment of the moon is like.
- The history of the exploration of the moon.
- Plans for future space stations on the moon.

ILLUSTRATION

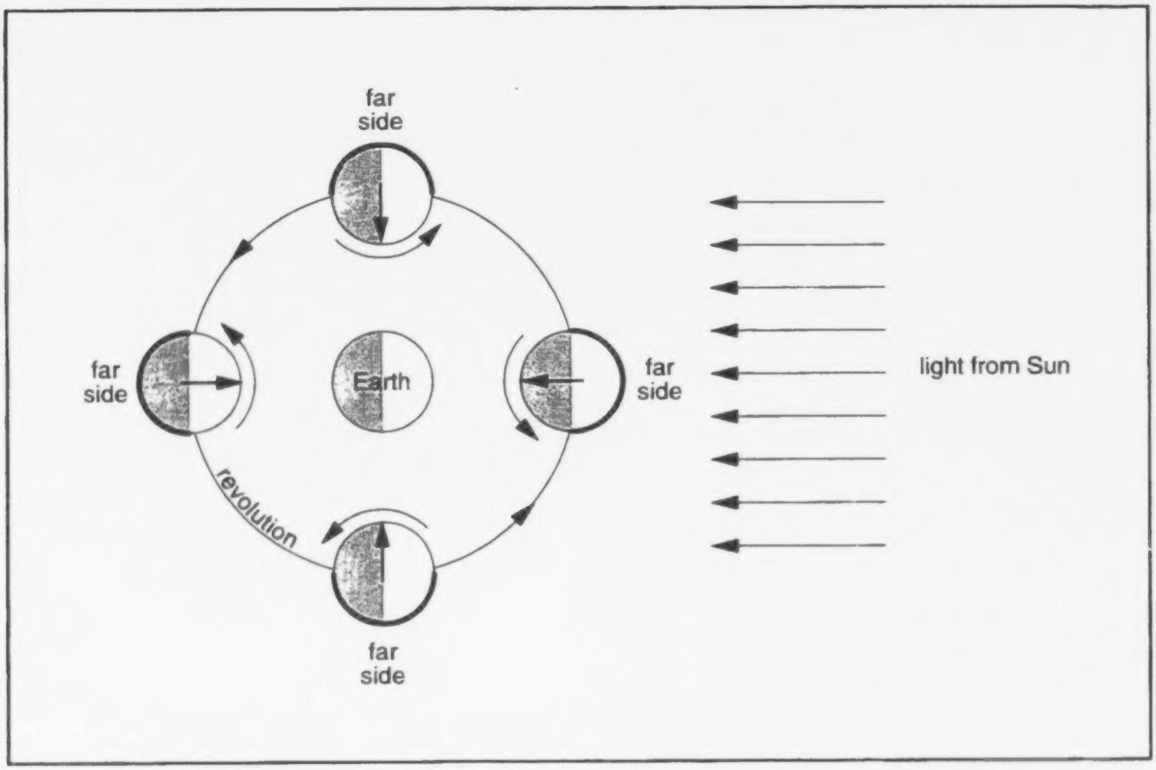

far side
far side
Earth
far side
light from Sun
revolution
far side

Figure 5.2.8 Model showing the rotation of the moon once each revolution around Earth. Arrows on the moon point to the middle of the moon's side that always faces Earth. To keep this orientation the moon must rotate on its axis. This can be seen by putting a pen with its clip facing Earth at the center of one of the moons. Hold the pen by its end. Move the pen around the orbit of the moon, at all time keeping the clip facing Earth. The pen will have to rotate to keep the clip facing Earth.

BEST COPY AVAILABLE

DASH

Name________________________

Date________________________

STUDENT PAGE 5.2.8 MOON THROUGH A TELESCOPE

1. **Draw the moon as you see it through a telescope or opera or field glasses. Record the place where observations were made, the moon phase, and the date of your observation. Label identifiable features on your drawings.**

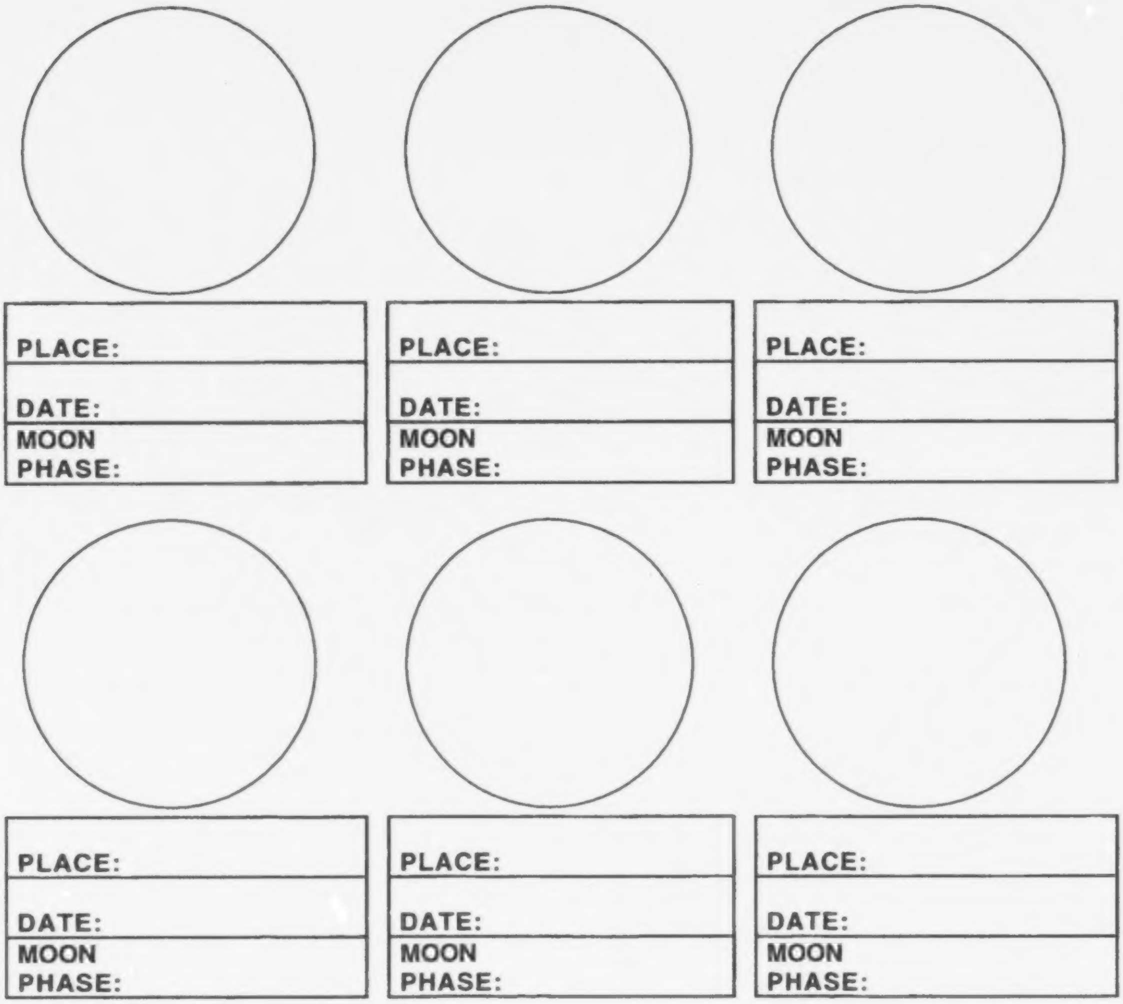

PLACE:
DATE:
MOON PHASE:
PLACE:
DATE:
MOON PHASE:
PLACE:
DATE:
MOON PHASE:
PLACE:
DATE:
MOON PHASE:
PLACE:
DATE:
MOON PHASE:
PLACE:
DATE:
MOON PHASE:

Figure SP 5.2.8(1) Diagrams of the moon as seen through a telescope or field or opera glasses

Name ______________________________

2. **Compare your diagrams with the view of the two sides of the moon shown in Figure SP 5.2.8(2). What part of the moon did you see?**

3. **On each of the circles representing the moon in Figure SP 5.2.8(3), shade the night side (the side not lighted by the sun). Draw an arrow from the center of the moon to the middle of the surface facing Earth. Follow your teacher's instructions to determine whether the moon turns on its axis.**

4. **Explain how Figure SP 5.2.8(3) can be used to show when the far side of the moon receives sunlight.**

5. **Explain what Figure SP 5.2.8(3) tells us about the rotation of the moon.**

6. **Explain what Figure SP 5.2.8(3) tells us about the length of a moon day and a moon night.**

ILLUSTRATIONS

Name ______________________________

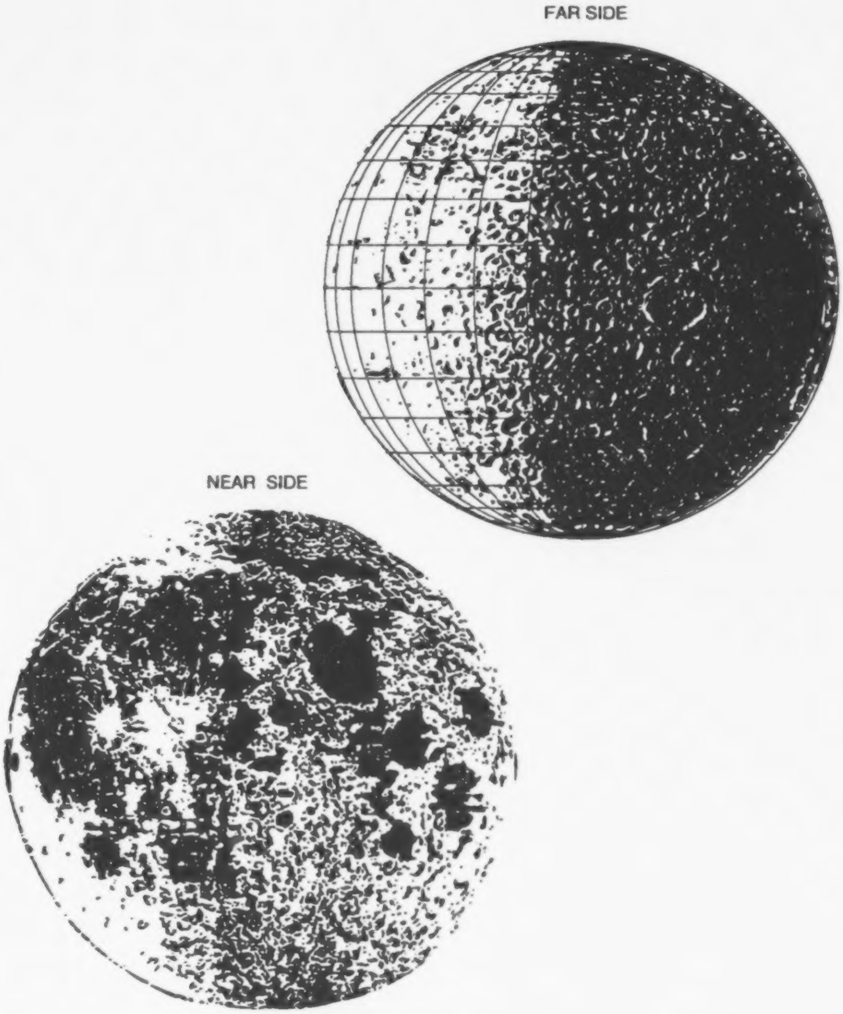

FAR SIDE
NEAR SIDE

Figure SP 5.2.8(2) The two sides of the moon

BEST COPY AVAILABLE

Name ______________________________

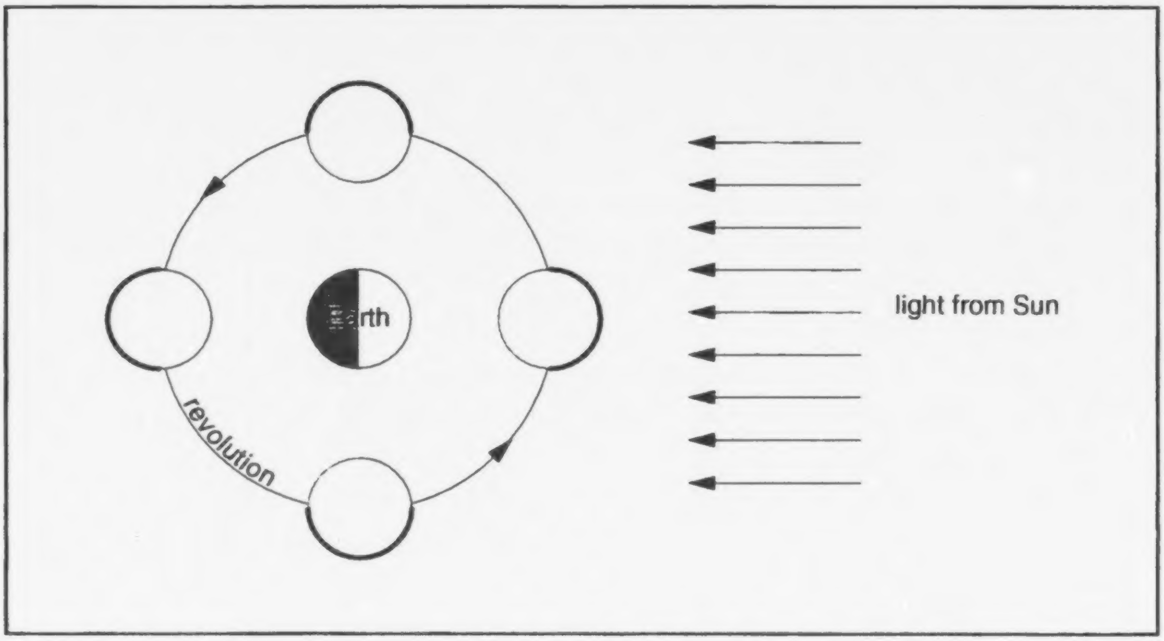

Earth
revolution
light from Sun

Figure SP 5.2.8(3) The moon's passage around Earth.

ACTIVITY 5.2.9
HOW BIG AND FAR AWAY IS THE MOON?

OBJECTIVES

The students
- Invent a way to determine the distance from Earth to the moon.
- Invent a way to determine the diameter of the moon.

BACKGROUND

In this activity the students get a feeling for how astronomers have used mathematics to determine the size of the moon and its distance from Earth. The activity should follow Activities 5.2.5 TRIANGLES, 5.4.5 MEASURING TREES, 5.2.7 SIZE OF EARTH, and 5.2.8 MOON THROUGH A TELESCOPE.

The Reading

Before they begin their exploration, have the students read the background materials in Student Page 5.2.9A HISTORY OF MEASUREMENT OF THE MOON where measurement of the distance from Earth to the moon is described. The measurement was done by *triangulation*. From two distant places on the Earth's surface telescopes were focused on the same spot on the moon at the same time. Imaginary lines connecting the two sites and the moon formed a triangle. The angles of this triangle and the distance between the observers were determined. By using these data and the technique of constructing similar triangles, the students can themselves determine the distance to the moon.

Use of a Scale Drawing

From the data given the students can draw their own triangle with angles of 89°, 89°, and 2° or they can use the triangle with the same angles shown in Figure SP 5.2.9A. From their previous work in Activity 5.2.5 TRIANGLES they found that the sum of the angles of a triangle is 180°.

In Activity 5.2.5 the students found that corresponding sides of similar triangles are proportional. Figure SP 5.2.9A shows a triangle with angles of 89°, 89°, and 2°. The triangle has a base of about 0.6 cm and the length of the other two sides is about 18.0 cm. The sides are about 30 times as long as the base:

18.0 cm ÷ 0.6 cm = 30.

It follows, then, that the distance to the moon must be about 30 times the distance between the observers:

30 x 7,750 = 232,500 miles or 30 x 12,400 km = 372,000 km.

The actual average distance is about 238,000 miles or 384,00 km.

Alternative

Triangle A in Figure 5.2.9 can be used with students who need a more concrete representation of distance. This triangle is scaled in mile units. The base representing the distance separating the astronomers referred to in the historical account is about 0.77 cm (7,700 miles), and the length of the sides is about 23.8 cm (238,000 miles). The ratio is 31 to 1. The scale is 1 cm equals 10,000 miles.

Determining the Moon's Diameter in Degrees

The moon's diameter can be determined in degrees from pole to pole. To do this, hold your index finger at arm's length and note how much of the finger's width is covered by the diameter of the moon. It will be about 1/4 of the finger's width, or 1/2 a degree. A finger's width is about 2 degrees. One fourth of 2° is 1/2°. This method can be used at any phase of the moon.

Determining the Diameter of the Moon in Miles

Some students may treat the problem of determining the diameter of the moon mathematically. For example if Earth's diameter as viewed from the moon is 2° and the moon's diameter as viewed from Earth is 1/2°, Earth's diameter would be about 4 times as large as the diameter of the moon. Earth has a diameter of 7,917 miles or about 8,000 miles; therefore, the moon would have a diameter of about 2000 miles. This is good logic and gives an answer very close to the actual diameter of 2,160 miles.

Some students will need a more concrete approach to finding diameter. A triangle with the moon's diameter as its base and the distance from Earth to the moon as its sides is also shown Figure 5.2.9. This triangle can be used to determine the moon's diameter. The length of the base is about 0.2 cm, and the length of the sides is 23.8 cm. In a 10,000 miles-per-centimeter scale the moon's diameter is about 2,000 miles.

STUDENT ROLES

Astronomer
Geometer

MATERIALS

pencil
ruler
students' metric tapes
protractors
Student Pages 5.2.9A HISTORY OF MEASUREMENT OF THE MOON
5.2.9B HOW BIG AND FAR AWAY IS THE MOON?

PRODUCTS

Completed Student Pages

PROCEDURES

1. **Introduce the problem of determining the distance to the moon. Help the students with the background reading in Student Page 5.2.9A HISTORY OF MEASUREMENT OF THE MOON.**

   Ask such questions as these:

   - What information did the astronomers use to find the distance to the moon? (Work to the idea that the astronomers found the base and the base angles of an imaginary triangle with its vertex on the moon. As the base they used the distance between each other in a straight line through Earth. The base angles were made by the intersection of sighting lines to the moon and the base through Earth. To do the sighting they used telescopes.)
   - Along a straight line through Earth, how far apart were the observers of the moon? (Work for agreement that they were about 7,750 miles or 12,400 km apart.)
   - Why was it necessary for the astronomers to do both observations of the moon at the same time? (Get at the idea that the moon moves quite fast, at a rate of about 15° per hour, and to get good data they needed to make sure there would be no shift in angle measurement due to the movement of the moon.)
   - How were astronomers able to get precise timing? (Help the students recall that the astronomers used the time of the occlusion of Spica by Mars.)

- Look at the angles the astronomers used. How was it possible to draw a triangle on paper similar to the one they visualized as stretching from Earth to the moon? (Work for agreement that to draw a similar triangle all one needs are three angles. Corresponding angles of similar triangles are equal. The astronomers knew two angles of the triangle, which were 89° and 89°. Because the sum of the angles of a triangle is 180°, the remaining angle was calculated to be 2° [180° – 89° – 89° = 2°].)

2. **Have the students work in small groups to find the distance to the moon. Use Figure 5.2.9 with groups that have difficulty with the more complex arithmetic involved in Figure SP 5.2.9A.**

3. **Have the students share their findings and techniques.**

Ask such questions as these:

- What distances did you find? (Have the groups report their answers. (Expect answers in the 220,000–240,000-mile range. The actual average distance is about 238,000 miles. In metric units the range will be 340,000–430,000 km with the actual average distance being 384,000 km.)
- What technique did you use to find the distance? (Some students may use the dimensions on the "globe" shown in Figure SP 5.2.9A, which shows measurements from Samarinda and Jama and the base angles. Using this diagram, they can extend the sighting lines of the moon until they meet. This can be done using two metric tapes. Solution from this diagram will give a fairly wide range of results. Other solutions may use the similar triangle shown in the same figure to compare the length of the sides to the length of the base. Honor other solutions.)
- What do we know about the sides of similar triangles? (Work to the idea that corresponding sides are proportional to each other.)
- In the small similar triangle what is the ratio of the long sides to the base? (Work for a ratio of 30–32 to 1.)
- If we know the size of the measured base of the triangle reaching to the moon to be 7,750 miles, how long would the other sides of the triangle be? (Work for the idea that they would be 30–32 times as long as the base [30 x 7,750 miles = 232,500 miles, 32 x 7,750 miles = 248,000 miles]. Validate their measurements by giving the measured distance to the moon, which is about 238,00 or 383,00 km.)

4. **Have the students go outside and use their forefinger to determine the diameter of the moon in degrees. (They will find that the diameter appears to be about a quarter the width of their finger. The total width of the forefinger is 2°. One-fourth of 2° is 1/2°.)**

5. **Present the following problem: We know the distance to the moon and have determined the diameter of the moon in degrees. When viewed from Earth, the diameter appears to be about 1/2°. Find a way to determine the moon's diameter in miles.**

6. **Have the students share their findings and techniques.**

   Ask such questions as these:
   - What distances did you find? (The moon usually will be found to have a diameter of between 1,900 miles and 2,300 miles [3,220–3,680 km]. This would be about 2,160 miles or 3,480 km.)
   - What technique did you use to find the distance? (Some students will correctly conclude that if the diameter of Earth as viewed from the moon is 2° and the diameter of the moon as viewed from Earth is 1/2°, Earth's diameter would be about 4 times as large. Earth's actual diameter is about 8,000 miles; therefore, the moon's diameter is about 2,000 miles. Another solution is to draw a triangle with a vertex angle of 1/2° and two base angles of 89.75° In Figure 5.2.9 the triangle with the moon's diameter as its base has these dimensions. Using the dimensions of this triangle will give answers in the range above.)

EXTENSION

- Have the students research the ways distances to the planets and stars are found.

ILLUSTRATION

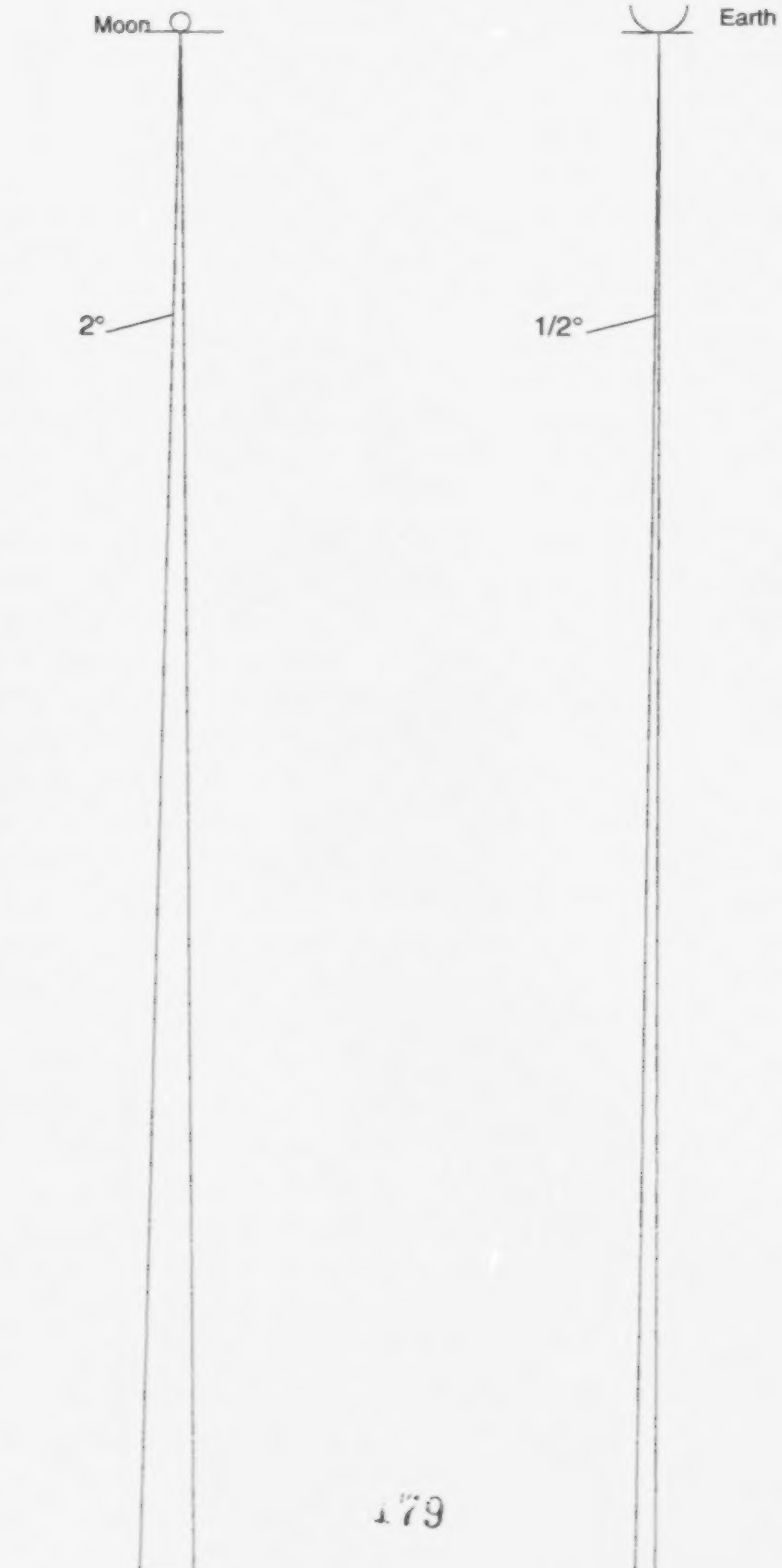

Moon
2°
(A) Earth
Earth
1/2°
(B) Moon

Figure 5.2.9 Scale drawings of triangles used to determine the distance to the moon and the moon's diameter

DASH

Name__________________________

Date__________________________

STUDENT PAGE 5.2.9A
HISTORY OF MEASUREMENT OF THE MOON

Trying to determine the distance from Earth to the moon was a wonderful mathematical game played by many ancient astronomers. The Greeks and Romans made observations that gave them distances ranging from Aristarchus's 12,000 miles to Hipparchus's 280,000 miles. These astronomers used the same method that we use to measure the height of trees—triangulation.

Problem of Finding Angles

Ancient astronomers knew how to measure the distance to the moon, but there was a problem. It is difficult to make angle measurements involving faraway objects, and they had to make their determinations using only the naked eye and very crude equipment. The invention of the telescope made the work much more exact.

Problems of Distance and Time

Because the moon is so far away, observers had to be far apart so that the angles would be large enough to make good calculations. This became possible when explorers began to travel to different parts of Earth. One problem remained, the observations had to be made at the same time. This problem was solved by having both measurements made when an occultation took place. An *occultation* is the eclipsing or passing of one celestial body in front of another, for example, when a planet passes in front of a star. Since it happens so far away, an occultation can be seen at almost exactly the same time in different parts of Earth. An occultation is a heavenly timer.

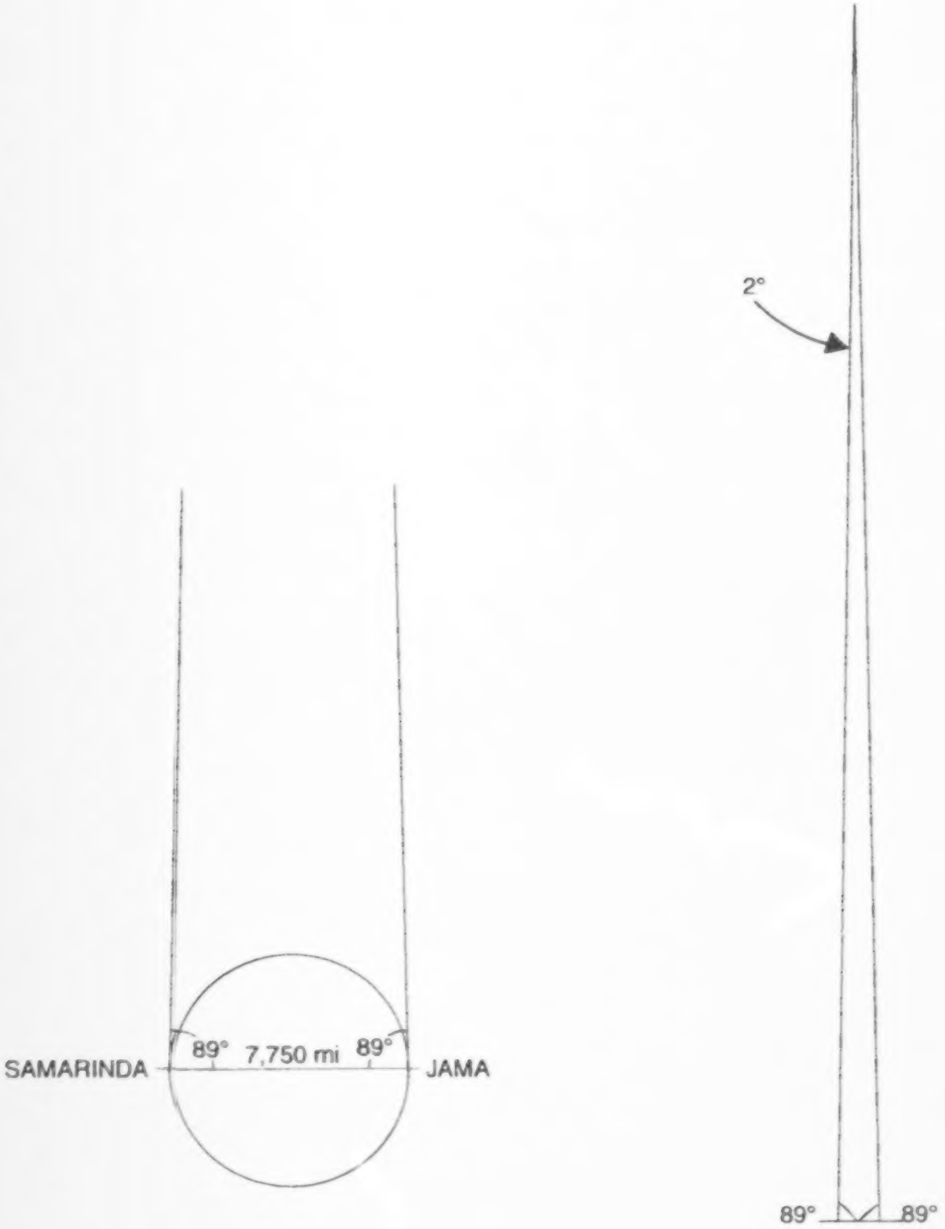
Name ______________________

Data

Some data will help us determine the distance to the moon. Let's say that two astronomers focus on the same spot on the moon at the moment that Mars occludes Spica. One is in Jama, Ecuador, which is just about on the equator at 81° W longitude. The other is in Samarinda, Borneo, which is just about on the equator at 118° E longitude. Each observer measures the angle of the moon in relation to an imaginary line that runs straight through Earth and joins the two locations. The angle made by the imaginary line to the spot on the moon and the imaginary line joining the observers is 89°. The length of the imaginary line joining the observers is approximately 7,750 miles or 12,740 km. See Figure SP 5.2.9A.

ILLUSTRATION

Name ______________________________


2°
89°
7,750 mi
89°
SAMARINDA
JAMA
89°
89°

Drawing of
a triangle with
base angles
of 89°

Figure SP 5.2.9A Diagram showing measurement of angles at Samarinda, Borneo, and Jama, Ecuador, and the distance between these sites.

DASH

Name______________________________

Date______________________________

STUDENT PAGE 5.2.9B
HOW BIG AND FAR AWAY IS THE MOON?

1. Use the data on the determination of the distance from Earth to the moon found in Student Page 5.2.9A HISTORY OF MEASUREMENT OF THE MOON. Explain how you made your calculations. Use diagrams as needed.

Name ____________________

2. Explain how you made your determination of the diameter of the moon. Use diagrams as needed.

____

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ACTIVITY 5.2.10
PATHS OF CELESTIAL BODIES

OBJECTIVES

The students
- Photograph the stars and planets as they move overhead at night.
- Observe and explain the apparent motion of some stars about the celestial pole throughout the night.

BACKGROUND

This activity provides evidence that the stars appear to travel about the pole star just as our models show. The activity should be done right before Activity 5.2.11 MODELS OF THE SOLAR SYSTEM and follow Activities 5.7.4 THE NORTH POLE, EQUATOR, AND ECLIPTIC and 5.7.5 WHERE IS EARTH?

Camera

Any camera can be used provided the shutter can be held open for an hour or two. Because the camera might be left outdoors unattended, it is better to use an old one. The students should be reminded that they should close the shutter when they complete their photographing. If a Polaroid camera is used, the students will not have to wait for the film to be processed.

Film

Black-and-white or colored film can be used. Have the students take several daylight shots of the site where the filming will take place. This will help others see how the project was carried out, and it will identify any objects that may be silhouetted in the night photos.

Site

Find a site where cameras can be placed facing the appropriate direction and no artificial light will reach them. The site should be sufficiently familiar to the students so that they can safely find the camera in the dark to open and close the shutter.

STUDENT ROLES

Astronomer
Photographer

MATERIALS

cameras with shutters that can be locked open
film
Student Page 5.2.10 PATHS OF CELESTIAL BODIES

PRODUCTS

Completed Student Pages

PROCEDURES

1. **Have the students use their Planetarium to make predictions about the paths of celestial bodies in the night sky.**

   Ask such questions as these:
   - How do we orient the Planetarium to show us how the stars move? (Help the students recall that the tip of the Planetarium is pointed in the direction of the North Pole.)
   - If we could photograph the north polar region all through the night, what would the movement of the stars look like in the photo? (Have the students use the Planetarium to make their predictions.)
   - If we could photograph the stars that rise in the east all through the night, what would the movement of the stars look like in the photo? (Have the students use the Planetarium to make their predictions.)
   - If we could photograph the stars that rise to the southeast all through the night, what would the movement of the stars look like in the photo? (Have the students use the Planetarium to make their predictions.)

2. **If the students have the capability of making such photos, have them organize into groups to make them.**

   Help the students
   - Organize so that at least two groups will photograph each of the following: the sky and horizon to the north, the east, and the southeast.
   - Agree when to start photographing and when to stop.

- Check the cameras intended for use to find out how the shutters can be kept open. (Have the students bring in the instruction manuals for their cameras if possible.)
- Do their photography according to their plan as checked by you.
- Show their photos and explain how they made them.
- Interpret their photos to show what was happening in the sky during the night.
- Date the photos.
- Interpret the photos and relate them to the Planetarium.

ALTERNATIVE

- Take photos yourself and have the students determine which were taken of the sky and horizon to the north, the east, or the southeast. Date the photos.
- Help the students interpret the photos and relate them to the Planetarium.

3. **Summarize the photographing of the stars.**

Ask such questions as these:

- How close were your predictions about the photos?
- How might we explain the circular path of the stars about the pole star Polaris? (Work to the idea that either the stars are moving about the pole star or Earth is turning.)
- How might we explain why the stars to the east of us appear to move directly overhead east to west. (Work to the idea that either the stars are moving or the Earth is turning.)
- How might we explain why the stars appear to move in arcs to the south? (Work to the same explanation that either the stars are moving or Earth is turning.)

4. **Extend the information gained from the photos to an exercise using their Planetariums.**

Ask such questions as these:

- If you were standing at the North Pole in the winter, what would the sky look like over a period of 24 hours? (Help the students see that if they look straight up into their Planetarium and turn it, they will have a picture of the sky above the North Pole. The stars will wheel around the *north* celestial pole [Polaris, the pole star].)

- If you were standing at the South Pole in its winter, what would the sky look like over a period of 24 hours? (Help the students see that if they turn their Planetarium upside down, it will look like the south polar sky and the stars will wheel around the *south* celestial pole.)
- If we look from the North Pole, why do we see only half the sky over the 24-hour period? (Get at the idea that Earth is in the way of the viewer at the poles. Only half the sky is overhead. The other half is always above the unseen Southern Hemisphere.)
- How much of the sky would you imagine one would see from the South Pole in 24 hours? (Get at the idea that Earth is also in the way of the viewer at the South Pole. Only half the sky is overhead. The other half is always above the unseen Northern Hemisphere.)
- If you were standing at the equator, what would the sky look over the 12 hours of night? (Have the students hold their Planetarium sideways and turn it. The southern cap of the Planetarium will be missing, but they should be able to imagine that they would see the sky all the way from the celestial north pole to the celestial south pole.)
- Why do we see all of the sky from the equator? For the viewer at the equator the part of the sky on the other side of Earth at sunset will have wheeled overhead by sunrise, only 12 hours later. The only stars that will not be seen will be those that are hidden by the sun.)

EXTENSION

- Have the students take photos of the night sky at other seasons. Have them predict ahead of time whether there will be differences in what is shown in the photos and what those differences might be.

DASH

Name________________________

Date________________________

STUDENT PAGE 5.2.10 PATHS OF CELESTIAL BODIES

1. Describe how a camera can be set to make a continuous photograph of the movement of the stars through the night. Use diagrams if needed.

2. How did you choose the site used for photographing?

3. What did you predict the photo would look like? Was your prediction verified?

Name ______________________

4. Explain what the photo tells us about the stars and planets. Use diagrams if needed.

ACTIVITY 5.2.11
MODELS OF THE SOLAR SYSTEM

OBJECTIVES

The students
- Review the astronomical data they have collected on the stars, planets, moon, sun, and Earth.
- Invent astronomical models of the movement of heavenly bodies.
- Compare their astronomical models with those of Ptolemy and Copernicus.
- Relate astronomical information to their models.
- Select the model they think is most reasonable.

BACKGROUND

This activity brings together astronomy studies from DASH K–5 and causes the students to create their own model of the movement of heavenly bodies. It then causes them to compare their model with classical Earth-centered and sun-centered models. MODELS OF THE SOLAR SYSTEM should come after Activities 5.7.3 MAPPING THE SKY, 5.7.4 THE NORTH POLE, EQUATOR, AND ECLIPTIC, and 5.2.10 PATHS OF CELESTIAL BODIES. It should be followed by 5.7.5 WHERE IS EARTH?

Approach

In MODELS OF THE SOLAR SYSTEM the intent is to put into question the idea that Earth is the center of the universe. The now-accepted model of a sun-centered solar system as a minor collection of moons and planets in a vast universe of stars runs counter to our observations. In the period of a day and night we see the bodies of the heavens apparently wheeling overhead. Even astronomers speak of the "rising" and "setting" of the stars, planets, sun, and moon, giving the impression that they circle about Earth.

In MODELS OF THE SOLAR SYSTEM the students compare models they have developed with the classical Earth-centered Ptolemaic system and the sun-centered Copernican system. They then test the models using information we now know about the sun, moon, planets and stars.

Student-Constructed Model

First, the students use Student Page 5.2.11A MODELS OF THE EARTH, SUN, PLANETS, AND STARS to summarize the astronomical information they know about the stars, planets, moon, Earth, and sun. They then are challenged to come up with their own model of the movement of these bodies to explain as much about the behavior of celestial bodies as they can.

Earth-Centered Model

Next they read about the Ptolemaic model in Student Page 5.2.11B PTOLEMAIC AND COPERNICAN MODELS. Ptolemy's model shows an Earth-centered universe in which the moon, sun, planets, and stars wheel overhead each day. Ptolemy assumed that the moon, sun, and planets pass in front of the stars because they can be seen to eclipse or "occlude" the stars. He also assumed that the moon is the closest celestial body to Earth because it eclipses all other bodies in its path and that its cycle of 29-1/2 days from new moon to new moon is the shortest cycle of movement of all the bodies in the heavens. A *cycle* is something that repeats and is measured as the time from start back to start.

Ptolemy's placement of the moon, visible planets, and the sun in the order shown in Figure SP 5.2.11B(1) was based on the time it takes the celestial bodies to go through their cycles. For the planets Mercury and Venus, a cycle was the time needed to complete a swing from rising before the sun in the morning to setting after the sun in the evening and back to rising before the sun in the morning. It takes Mercury 88 days to complete this cycle and 224 days for Venus to complete it. Because of its shorter cycle, Mercury was assumed to be closer to Earth than Venus. Ptolemy measured the cycles of the sun, Mars, Jupiter, and Saturn as the time they need to move through the Zodiacal Band. The sun takes 365 days; Mars, 687 days; Jupiter, 12 years; and Saturn, 30 years. Using the bodies' cycles to determine distance, he assumed that the moon must be closest to Earth followed by Mercury, then Venus, the sun, Mars, Jupiter, and Saturn.

Ptolemy accounted for the movement of Mercury and Venus from one side of the sun to the other by assuming that the planets travel in little circles called *epicycles* in their orbit about Earth. An epicycle in front of the sun would place Mercury and Venus alternately on the rising side and the setting side of the sun. See Figure 5.2.11.

Sun-Centered Model

The students next read about the Copernican model of the solar system, which describes a sun-centered model. Though this model has been modified by later observation, it has generally held up for the last 500 years. In the Copernican model all the planets, including Earth, orbit the sun. Stars remain stationary and night and day are produced by the turning of Earth on an axis. See Figure SP 5.2.11B(2).

Class Simulation

After comparing descriptions of their own model with the models of Ptolemy and Copernicus, the students simulate how the three models would work by acting out how the planets, Moon, Earth, and stars would move according to each model. When they simulate the Ptolemaic model, they find that the constellations and outer planets would have to move very fast to go around Earth each day. This is like a chain of people in a game of crack-the-whip; the people near the center move relatively slowly and the ones at the end very fast.

In the Copernican model there would be a much slower movement of all bodies because they take such a long time (sometimes years) to revolve around the sun. Body movement in the students' model will depend on how they have constructed it.

Logic and the Models

The students next test how logic supports the three models in different situations. They are asked to speculate on what would happen if a rocket were sent from Earth to the outer planets in the Ptolemaic and Copernican models. In the Ptolemaic model the sun in its daily swing across the sky would probably collide with the rocket. The diameter of the sun is huge (864,000 miles). Our present rockets go about 35,000 miles per hour or 840,000 miles per day and would have a difficult time getting past the sun. There would be no collision in the Copernican model because the sun would not be moving between Earth and the planets. What would happen in the students' model will depend on its construction.

The students are then asked to investigate the speeds of heavenly bodies as they orbit Earth. They will find that in the Ptolemaic model the stars would have to travel faster than the speed of light (186,000 miles or 300,000 km per second). According to our present understanding, nothing moves faster than the speed of light. See Table SP 5.2.11A-1. In the Copernican model heavenly bodies would travel relatively slowly. See Table SP 5.2.11A-2.

Finally, the students look at what we now know about the distances of the planets from Earth to see whether the Ptolemaic and Copernican models seem reasonable. If we use the more modern data found in Tables

SP 5.2.11A-3 and 4 with the Earth-centered Ptolemaic model, the planets would be in a different sequence from the one suggested by Ptolemy. Venus would be next to Earth followed by Mars, followed Mercury and the sun. This would be very different from the models suggested by Ptolemy. If we use modern data with the Copernican model, the planets would appear in the same order we know them today—the sun at the center followed by Mercury, Venus, Earth, moon, Mars, Jupiter, and Saturn.

Modern Acceptance of the Copernican Model

Historically the sun-centered model Copernicus produced in 1543 appeared to be so contrary to daily observation that it was not accepted until the astronomers began to use the telescope. Galileo used the astronomical telescope in 1608. Over time other observers collected data on the distance of the planets and sun from Earth and on their size. The telescope revealed that Mercury and Venus did pass around the sun. With these data Earth-centered models were shown to be improbable.

Between 1609 and 1619 Johannes Kepler published his theory of elliptical orbits. In 1687 Isaac Newton published his gravitational theory, which refined the sun-centered model so that it could become predictive. Over the next 300 years the existence of three additional planets, their moons, and a host of asteroids was predicted and found. Earth was displaced from the center of the universe and given a humble position among the nine planets of a minor star in a commonplace galaxy now known to be the home of possibly countless planetary systems.

For now, it is enough to see how our commonsense observations of the movements of heavenly bodies can be explained by the turning of Earth on its axis and the relatively slow revolution of planets around the sun. With this understanding the students have a grounding for more mathematical arguments of Kepler and Newton that can be addressed later.

Modern Use of the Earth-Centered Model

The language of an Earth-centered model is used today in almanacs and astronomical guides because it describes what we see. We see the rising and setting of the sun, moon, planets, and stars and their apparent passage across the sky. Though useful in thinking about the sky, it is now understood that the model that better describes the operation of our solar system is basically the one worked out by Copernicus. This points up the important lesson that an explanation or model may work and be useful for many things and may allow us to make many predictions, but it may not be the best explanation. For this reason scientists need to be alert for better explanations as well as useful models.

STUDENT ROLE

Astronomer

MATERIALS

Planetariums from Activity 5.7.2 PLANETARIUM
Student Page 5.2.11A MODELS OF THE EARTH, SUN, PLANETS, AND STARS
5.2.11B PTOLEMAIC AND COPERNICAN MODELS

PRODUCTS

Models of the solar system
Working definitions
Completed Student Pages

PROCEDURES

1. **Point out that we have a model of the moon's revolution about Earth and have seen how it can explain the phases of the moon. We now need to find a model that will show how the stars, planets, moon, Earth, and sun move in space.**

   Ask such questions as these:
   - What do we mean by the term model? (Work to the idea that a *model* may be a small copy of something such as a model car. It may show how a thing such as a jet engine works. It may be something that we might or might not want to copy such as a model of behavior. It may take the form of a diagram, a picture in our head, something we can handle, or a mathematical equation that tells about quantitative relationships. Help the students develop a definition of the term for the Working Dictionary.)
   - What are the characteristics of our moon-phase models? What do they tell us? (Get at the idea that they tell us how the moon, Earth, and sun work together to produce phases.)
   - What do we mean by the term system? (Get at the idea that a system is made up of things that are connected or work together in some way. Help the students develop a definition of the term for the Working Dictionary.)
   - What would be the characteristics of a model showing the movement of the planets, sun, and stars? (Get at the ideas that it

should be of manageable size and should show how the planets, stars, and sun move in relation to each other.)

2. **Have the students work in small groups to list the things they know about Earth and its relationship to other heavenly bodies. Have them use Student Page 5.2.11A MODELS OF THE EARTH, SUN, PLANETS, AND STARS. Make a master class list of things known.**

   Ask such questions as these:
   - From our viewpoint on Earth how does the sun seem to behave differently from the other stars? (Get at any selection of things such as the following: The other stars can be seen at night and the sun is seen during the day. The other stars always seem to rise and set at the same place, while the sun moves north and south along the eastern horizon in its rising and along the western horizon in its setting. The times when certain stars are visible in the night heavens change with the seasons. The stars of the Zodiacal Band rise and set at different times throughout the year. Some stars, the stars around the pole, are always in the sky throughout the night.)
   - How is the moon like Earth? (Get at such things as the moon's mountains and plains make it look a bit like Earth through a telescope, the moon and Earth have both a night side and a day side, the moon and Earth get their light from the sun on the side facing the sun, they both are spheres, and so forth.)
   - From our viewpoint on Earth how do the planets appear to be similar to and different from the stars? (Get at such things as they are alike in that both are seen at night, they both look like pinpoints of light, and they both rise in the east and set in the west. They are different in that the planets move back and forth and up and down in front of the stars while the stars seem to be fixed in their path in relation to each other, and so forth.)

3. **Have the students work in groups to devise models of the way the stars, sun, moon, planets, and Earth might be distributed and move in the heavens.**

4. **Have the students describe their models, discuss them, and vote on the most acceptable model to explain the movement of the stars, sun, moon, planets, and Earth. This model becomes the class model.**

5. **Have the students read about Ptolemy and his model in Student Page 5.2.11B PTOLEMAIC AND COPERNICAN MODELS.**

Ask such questions as these:

- Why do you think Ptolemy put the moon closest to Earth in his model? (Get at the idea that the moon can pass in front of all the stars, the sun, and the planets eclipsing or "occulting them." If the stars and planets passed in front of the moon, we would see spots moving across the face of the moon.)
- Why do you think Ptolemy put Mercury and Venus in orbits making little circles as they travel with the sun? (Take all answers. See Figure 5.2.11. Both Mercury and Venus are seen right before sunrise or right after sunset and never for the entire night. Good eyes may see them traveling with the sun during the day. According to Ptolemy, the planets revolve in circles called *epicycles* as they pass around Earth with the sun. When they are in the part of the epicycle on the morning side of the sun, they will be seen in the morning and when on the opposite side of the sun they will be seen in the evening.)
- Why do you think Ptolemy put Mars, Jupiter, and Saturn beyond the sun? (Like the stars, these outer planets are sometimes up throughout the night. Like the sun, they pass through the Zodiacal Band but take longer than the sun to get back to where they were first observed. Ptolemy put them in the order of the length of time it takes them to travel through the Zodiacal Band.)
- Why do you think Ptolemy put the stars outside the planets? (All the planets can be seen to pass in front of stars. The stars never seem to change their position in the sky relative to each other. Ptolemy assumed that they must all be alike but different from the planets, moon, and sun.)
- In the Ptolemaic model, how often must the sun, moon, planets, and stars wheel around Earth? (Get at the idea that this model calls for such a movement once each day.)
- How many of your own models of the planets, sun, and stars look like Ptolemy's?

6. **Have the students read about Copernicus and his model in Student Page 5.2.11B PTOLEMAIC AND COPERNICAN MODELS.**

Ask such questions as these:

- If we look at the location of the sun and planets, how does the Copernican model differ from the Ptolemaic? (Help the students identify the positions of the planets with the sun at the center of the Copernican solar system. Earth and the sun have changed places in the two models.)

- How does the Copernican model account for the movement of Venus and Mercury? (They go around the sun as the moon goes around Earth. They will be up in the morning and evening only because they do not pass on the night side of Earth as all the outer planets do. Outer planets are those beyond Earth and include Mars, Jupiter, and Saturn.)
- How would it be possible for the sun, planets and stars to wheel overhead each day and night in such a model? (Work for the idea that Earth would have to turn on an axis or rotate. The following mnemonic may be helpful in remembering the distinction between rotation and revolution.

One **rotation** defines the day's **duration.**
One **revolution** defines a year's **evolution.**

- How many of your own models of the planets, sun, and stars look like the Copernican model?

7. **Have members of the class simulate the stars, sun, moon, planets, and Earth as they would move in the Ptolemaic model. Have them use Figure SP 5.2.11B(1) as a guide.**

While the students are setting up the model ask such questions as these:

- What is Earth like in the Ptolemaic model? (Help the students recall that it is a stationary globe in the Ptolemaic model. Select a person to represent Earth.)
- To simulate Earth, what will our "Earth" person have to do? (Get at not moving and always looking the same way.)
- In what order do the moon, visible planets, and sun come as they circle Earth? (Select students to be the moon, Mercury, Venus, the sun, Mars, Jupiter, and Saturn and place them in order at two to three arm lengths from each other.)
- What comes next? (Help the rest of the students form a great outer circle to represent the stars of the Zodiacal Band. You may want to have them review the constellations in the Zodiacal Band and take zodiacal names.)
- According to the Ptolemaic model, what will happen to all of the heavens in one 24-hour period? (Work toward moving the entire

herd of heavenly bodies about the stationary Earth. The outer stars will have to move quite fast.)

- One week later what will the heavens look like? (Mercury and Venus will travel in their epicycles and the moon in its orbit. The outer planets will advance through the Zodiacal Band and the twelve constellations will advance a little.)
- One month later what will the heavens look like? (The previous events will have advanced, and the moon will be back where it was in the first simulation.)

8. **Have members of the class simulate the stars, sun, moon, planets, and Earth in the Copernican model. Have them use Figure SP 5.2.11B(2) as a guide.**

Ask such questions as these:

- How would we change the location of the planets and the sun in the Ptolemaic model to make a solar system according to the Copernican model? What would be at the center? (The sun would be at the center in the Copernican model, and Earth would be the third planet out.)
- What is the order of the visible planets? (Mercury, Venus, Earth, Mars, Jupiter, Saturn.)
- Where would the stars be? (In the same place as in the Ptolemaic model.)
- What will have changed? (Only the sun and Earth have moved.)
- How can we account for the daily movement of the planets and the sun and the moon and the stars overhead? (Get at the idea of Earth making one turn on its axis every day. Have the student who is Earth demonstrate this.)
- What would be changed a week later? (Get at the idea that the moon would have moved 90° in its revolution around Earth. The planets would all have moved slightly forward, and the sun and other stars would remain fixed.)

9. **Use members of the class to simulate the Earth, sun, moon, planets, and stars in the class model.**

Ask such questions as these:

- How are the three models different?
- So far, which model seems the most reasonable? Why?

10. **Have the students use diagrams of the models to help find additional reasons supporting the different models.**

Ask such questions as these:

- What would happen to a rocket traveling 35,000 miles per hour toward Mars in the Ptolemaic, the Copernican, and the class model? (In the Ptolemaic model the rocket would have to dodge the sun or run into it. The sun is so large and the speed of our rockets so slow that the rocket could not dodge it. In the Copernican system the sun would not be in the path of the rocket. What would happen in the class model is open to discussion.)
- Did the rockets we have shot toward Mars and other space targets hit the sun? (NO.)

11. **Have the students use Tables SP 5.2.11A-1 and 2 to help find additional reasons supporting the different models.**

Ask such questions as these:

- How far away is the sun? (The sun is about 93,000,000 miles from Earth.)
- How far would the sun have to travel in 24 hours in its orbit according to the Ptolemaic model? In one second? (The circumference of the orbit of the sun is about 580,000,000 miles. This means that the sun would have to travel 580,000,000 miles in 24 hours. That would be about 6,700 miles per second.)
- The nearest star is 4-1/2 light years away from Earth, which is about 26,400,000,000,000 or 26.4 trillion miles. About how many miles per second would it have to travel to get around Earth in a day? (About 306,000,000 miles per second.)
- The speed of light seems to be our speed limit, and it is 186,000 miles per second. What can we say about the speeds expected of the stars in the Ptolemaic model? (The stars would exceed the speed of light if they traveled in Ptolemaic orbits. Einstein's Theory of Relativity indicates that 186,000 miles per second is the speed limit for matter and energy.)
- What is the circumference of Earth at its equator? (Work to a circumference of about 24,900 miles.)
- In the Copernican model, how fast would Earth rotate in an hour? In a second? (At the equator the rate that Earth turns would be a little more than 1,000 miles per hour or 0.27 miles per second.)
- In the Copernican model, how fast would Earth revolve about the sun in a day? In a second? (The circumference of Earth's orbit around the sun is about 580,000,000 miles. It would take Earth 365 days to travel that far. That would be about 1,590,000 miles per day or 18 miles per second.)

- In the Copernican model, how fast would the stars travel around the sun? (In the Copernican model the stars would not move.)
- Does the class model have problems when the known distances are used? If so, what are they?
- From the standpoint of the speed with which bodies would move, which model seems more reasonable? (The Copernican model seems the most reasonable because the Ptolemaic model presents some impossibilities.)

12. Have the students review the data from the Tables SP 5.2.11A-3 and 4 to look for logical support for the different models they have explored.

Ask such questions as these:

- Do the known distances support the Ptolemaic model? (NO. In the Ptolemaic model, Venus at its nearest point to Earth would be the closest planet to Earth, Mars would be the second closest, and Mercury would be the third closest. This contradicts the Ptolemaic model, which states that the order of the heavenly bodies is Earth in the center followed by Mercury, Venus, the sun, and Mars.)
- Do the known distances given for Venus support the Copernican model? (YES. Work to the idea that the known distances support the Copernican model because in that model Venus would be between Earth and the sun and would come closest to Earth. When it passes on the far side of the sun, it would be farther away from the sun than Mercury. It would never be seen throughout the night because it would not pass on the night side of Earth.)
- Do the known distances given for Mars support the Copernican model? (YES. Work to the idea that the known distances support the Copernican model because Mars would be the second closest planet to Earth, but it would be farther from the sun than Earth. It would be seen throughout the night because it would pass on the night side of Earth. When on the far side of the sun, it would be farther away from Earth and the sun than Venus.)
- Do the known distances given for Mercury support the Copernican model? (YES. Work to the idea that the distances support the Copernican model because Mercury would be between Earth and the sun and would be the closest planet to the sun. When Mercury passes on the far side of the sun, it would always be closer to the sun than Venus. It would never be seen throughout the night because it would not pass on the night side of Earth.)
- Do the distances given for Jupiter and Saturn support the Copernican model? (YES. Work to the idea that the distances support the

Copernican model because they show the two planets as being farther out from the sun than Mars as predicted by both the Ptolemaic and Copernican models.)

- Do the known distances from Earth agree with the distances from the sun in the Copernican model? (YES. Have the students look at the model in Figure SP 5.2.11B[2]. Work for consensus that the distances agree. In the Copernican model the planets would have some time when they would be on the opposite side of the sun from Earth and some time when they would be on the same side. When they are on the opposite side of the sun, they would be farther away from Earth than when they are on the same side as Earth. Because the planets revolve around the sun, they would always be about the same distance from the sun.)

13. **Open discussion by asking which of the models seems to fit the information we have today the best.**

EXTENSION

- Have the students use the data from Table SP 5.2.11A-4 to simulate the Copernican model showing the relative distances of the moon, sun, and planets. Have them let 1 foot (1/3 meter) equal 10 million miles. Have them use a volleyball for the sun and small round-headed pins for Mercury, Venus, Earth, Mars, and Pluto, a Ping-Pong ball for Jupiter, and marbles for Neptune and Uranus. Usually the school playing field will be large enough to fit in Uranus.

ILLUSTRATION

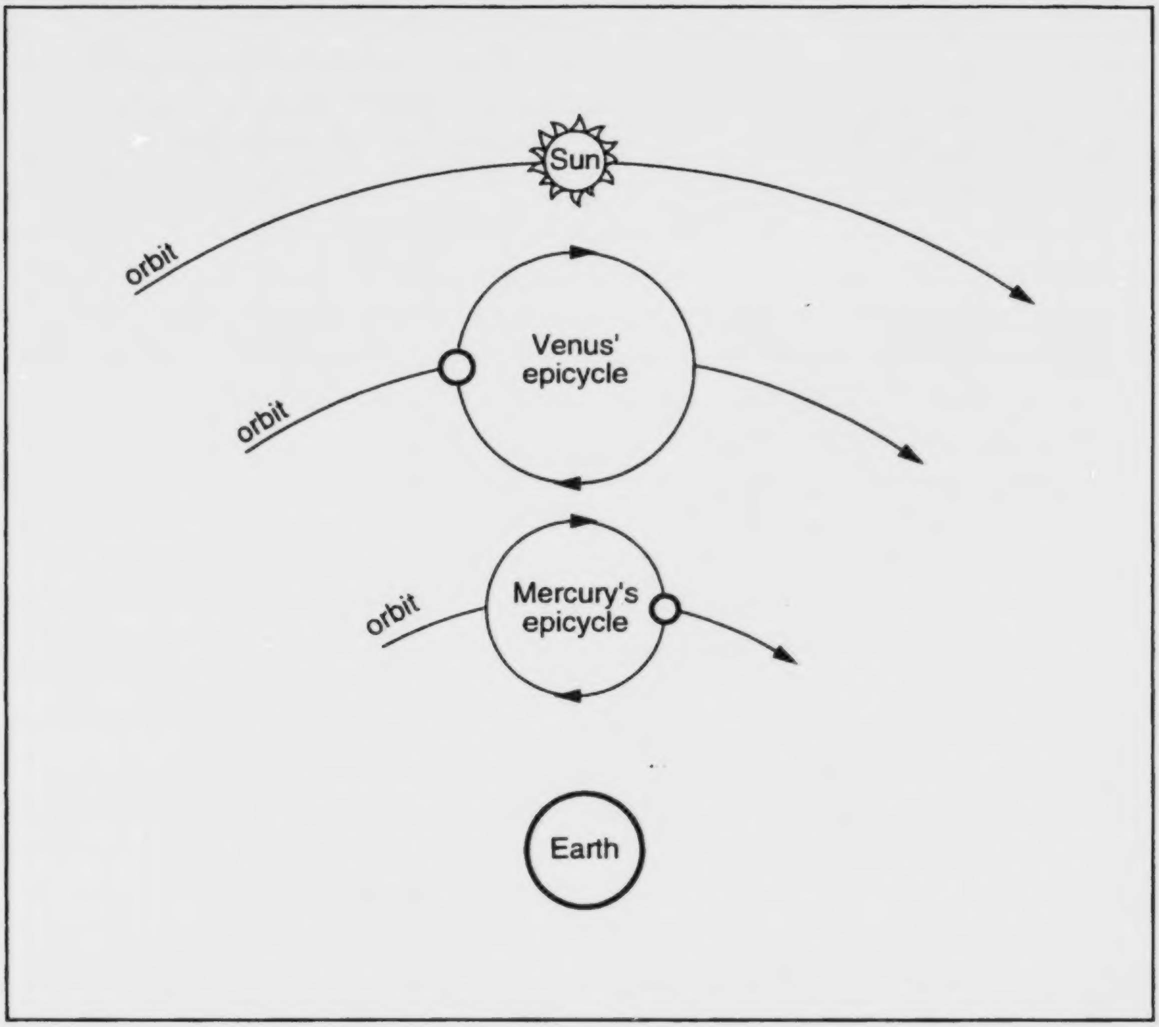
Sun
orbit
Venus' epicycle
orbit
Mercury's epicycle
orbit
Earth

Figure 5.2.11 Ptolemy's map of the heavens showing the epicycles of Mercury and Venus

DASH

Name________________________

Date_________________________

STUDENT PAGE 5.2.11A
MODELS OF EARTH, SUN, PLANETS, AND STARS

1. List the things you know about Earth and its relationship to other heavenly bodies.

2. Create a model to show the movement of the moon, sun, planets and stars as they move in the heavens throughout the day and night over the year. Draw your model below.

Name ______________________________

3. **Read the account of Ptolemy's model of the universe. See Student Page 5.2.11B PTOLEMAIC AND COPERNICAN MODELS. Compare your model with Ptolemy's. Are there things that Ptolemy's model accounts for that your model does not include? If so, list them.**

4. **Read the account of Copernicus model of the universe in Student Pages 5.2.11B PTOLEMAIC AND COPERNICAN MODELS. Compare your model with Copernicus's. Are there things that Copernicus accounted for that your model does not include? If so, list them.**

Name ______________________________

5. Compare Ptolemy's model with Copernicus's. List any differences.

6. Which of the models seemed the most reasonable when members of the class represented the heavenly bodies? Explain your reasoning.

7. According to the Ptolemaic, the Copernican, and class models what would happen to a rocket shot toward Mars?

Name ______________________________

8. **How do the data in the Tables SP 5.2.11A-1 and 3 support any or all of the different models you have used?**

9. **Of the three models, which is the most believable? Explain your thinking.**

Name ______________________________

Table SP 5.2.11A-1 Data implied by the Ptolemaic model

BODY	CIRCUMFERENCE OF ORBIT	REVOLUTION AROUND EARTH	ORBITAL SPEED AROUND EARTH
Earth	—	—	—
Mercury	223,000,000 mi	1 day 86,400 sec	223,000,000 mi/day 2,600 mi/sec
Venus	415,000,000 mi	1 day 86,400 sec	415,000,000 mi/day 4,800 mi/sec
Sun	580,000,000 mi	1 day 86,400 sec	580,000,000 mi/day 6,700 mi/sec
Mars	874,000,000 mi	1 day 86,400 sec	36,400,000 mi/day 9,700 mi/sec
Jupiter	2,990,000,000 mi	1 day 86,400 sec	2,990,000,000 mi/day 35,000 mi/sec
Saturn	5,600,000,000 mi	1 day 86,400 sec	5,600,000,000 mi/day 65,000 mi/sec
Nearest Star	26,400,000,000,000 mi	1 day 86,400 sec	26,400,000,000,000 mi/day 306,000,000 mi/sec

Note: Approximate numbers

Table SP 5.2.11A-2 Data implied by the Copernican model

BODY	CIRCUMFERENCE OF ORBIT	REVOLUTION AROUND THE SUN	ORBITAL SPEED AROUND THE SUN
Sun	—	—	—
Mercury	223,000,000 mi	88 days 7,600,000 sec	2,530,000 mi/day 29 mi/sec
Venus	415,000,000 mi	224 days 19,400,000 sec	1,850,000 mi/day 21 mi/sec
Earth	580,000,000 mi	365 days 31,500,000 sec	1,590,000 mi/day 18 mi/sec
Mars	874,000,000 mi	687 days 59,400,000 sec	1,270,000 mi/day 15 mi/sec
Jupiter	2,990,000,000 mi	4380 days 378,000,000 sec	683,000 mi/day 8 mi/sec
Saturn	5,600,000,000 mi	10,900 days 945,000,000 sec	511,000 mi/day 6 mi/sec
Nearest Star	—	—	—

Note: Approximate numbers

Name ______________________________

Table SP 5.2.11A-3
Currently known distances from Earth

BODY	DISTANCE FROM EARTH IN MILLIONS OF MILES
Moon	0.24
Sun	93
Mercury	50 to 136
Venus	25 to 161
Mars	35 to 248
Jupiter	367 to 600
Saturn	744 to 1,028
Uranus	1,606 to 1,960
Neptune	2,677 to 2,910
Pluto	2,570 to 4,700

Note: Approximate numbers

Table SP 5.2.11A-4
Currently known data about the heavenly bodies

BODY	AVERAGE DISTANCE FROM SUN IN MILES	REVOLUTION AROUND THE SUN	ROTATION TIME	DIAMETER IN MILES
Sun	—	—	26 days	864,000
Mercury	36,000,000	88 days	59 days	3,025
Venus	67,000,000	224 days	244 days	7,526
Earth	93,000,000	365 days	1 day	7,927
Mars	141,000,000	687 days	1 day	4,218
Jupiter	483,000,000	12 years	10 hr	88,700
Saturn	886,000,000	29.5 years	10 hr	75,100
Uranus	1,780,000,000	84 years	22 hr	32,000
Neptune	2,790,000,000	164 years	23 hr	31,000
Pluto	3,660,000,000	248 years	6.4 days	2,500
Nearest Star	2,640,000,000,000	—	unknown	unknown
BODY	**AVERAGE DISTANCE FROM EARTH IN MILES**	**REVOLUTION AROUND EARTH**	**ROTATION TIME**	**DIAMETER IN MILES**
Moon	238,000	28 days	28 days	2,160

Note: Approximate numbers

Name______________________

Date_______________________

DASH

STUDENT PAGE 5.2.11B
PTOLEMAIC AND COPERNICAN MODELS

PTOLEMY

Some eighteen hundred years ago there lived in the seaport city of Alexandria, Egypt, the astronomer Claudius Ptolemaeus whom we now call Ptolemy. He invented an Earth-centered model of the heavens showing the movement of the stars, planets, moon, sun, and Earth that was used by astronomers until very recent times

Ptolemy had no telescopes. Using what he saw and could reason, he concluded that because Earth is so large compared to the bodies seen in the heavens, it does not move. From observations of the moving bodies in the heavens he gave them all orbits or pathways that passed around Earth. The planets that Ptolemy knew were Mercury, Venus, Mars, Jupiter, and Saturn. He said the orbits of the planets, sun, and moon all were on a plane or flat surface because they follow the same path (the ecliptic) across the sky.

In addition to their daily passage about Earth, the planets regularly move back and forth against the background stars. To account for this Ptolemy said they must travel in circles as they orbit Earth. These circles he called *epicycles*. He explained that Mercury and Venus are seen only in the morning and evening because of their movement in epicycles in front of the sun.

He reasoned that the moon and the planets all occluded (passed in front of) the stars; therefore, the stars must be the farthest away from Earth. The relative distance of the moon and planets he determined by the time that it takes them to go through their cycles.

Name ______________________

The moon goes through its cycle from new to full and back to new in about 29-1/2 days. Mercury goes from its first appearance on the morning side of the sun to the night side and back to the morning side in 88 days. Venus goes through the same cycle in 224 days.

For the cycle of the sun and the other planets he used the time it takes them to travel through the Zodiacal Band. It takes the sun 365 days, Mars 685 days, Jupiter 12 years, and Saturn 30 years. His order, then, of relative distance from Earth was the moon nearest, then Mercury, Venus, the Sun, Mars, Jupiter, and Saturn. His model looked like Figure SP 5.2.11B(1).

Ptolemaic Model

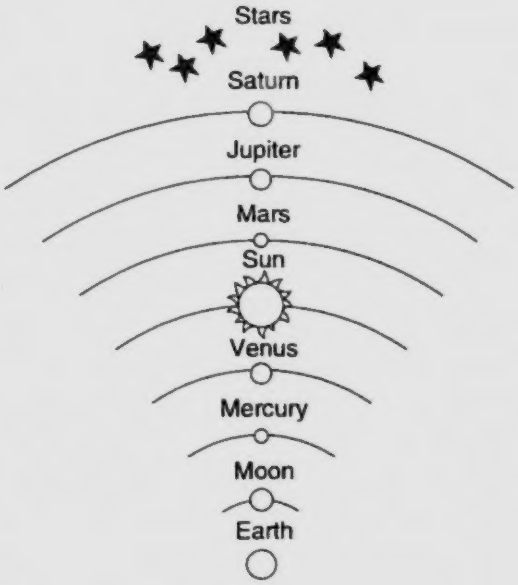

Figure SP 5.2.11B(1) Ptolemy's model of the moon, planets, sun, stars, and Earth

Name ______________________________

COPERNICUS

Nicolaus Copernicus was born in Poland in 1473. He studied mathematics and astronomy and earned doctoral degrees in church law and medicine. Though he worked as an administrator of the Catholic church and as a medical doctor, his great love was astronomy. He knew the solar system model of Ptolemy well.

At the time Copernicus lived, navigators were attempting to use Ptolemy's system to predict eclipses of the planets and stars to help them find their longitude or how far west or east they were from their home ports. The predictions were often found to be too far off to be very helpful. Rather than try to repair Ptolemy's work, Copernicus said the logic for the model was wrong, so he set about devising a sun-centered model.

Copernicus started his work on his idea of the solar system in 1506. For the next 35 years he labored and received the first copy of the book in which he reported his model a few hours before his death in 1543. He titled his book *Revolutions of Heavenly Spheres*.

His model looked like the one shown in Figure SP 5.2.11B(2). Note that the sun is in the center and all the planets revolve about it. As in Ptolemy's model, the sun, planets, moon and Earth are drawn on the plane of the ecliptic. The stars do not move, and the apparent daily movement of the heavens is due to the turning of Earth on its axis and Earth's traveling around the sun.

Name ______________________

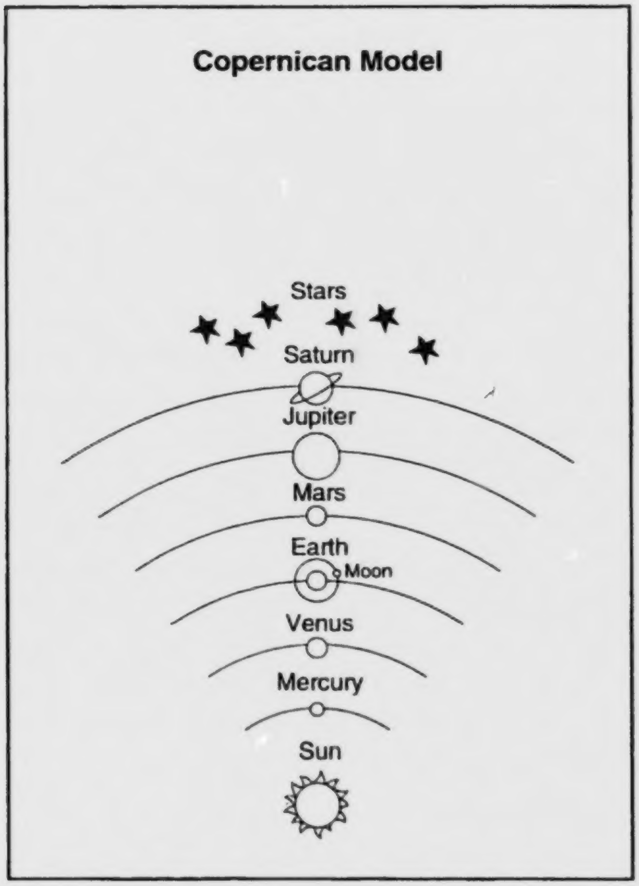
Copernican Model
Stars
Saturn
Jupiter
Mars
Earth
Moon
Venus
Mercury
Sun

Figure SP 5.2.11B(2) Copernicus's model of the moon, planets, sun, stars, and Earth

DASH

Name________________________

Date________________________

STUDENT PAGE 5.2.1 WEATHER STATION

Make diagrams of any equipment and logos you devised to carry out the procedures listed below. Describe how the equipment works.

- Reading indoor and outdoor temperatures
- Measuring wind direction
- Measuring wind speed
- Measuring rainfall or snowfall
- Measuring humidity
- Recording general weather conditions using logos
- Calculating wind chill

DASH

Name________________________

Date________________________

STUDENT PAGE 5.2.2A HEAT INDEX

1. Explain what is meant by the heat index.

2. Describe the symptoms of people suffering from heat exhaustion and heat stroke.

3. Describe what should be done for people suffering from heat exhaustion and heat stroke.

DASH	**SP 5.2.2B HEAT INDEX CHART**	Name __________ Date __________

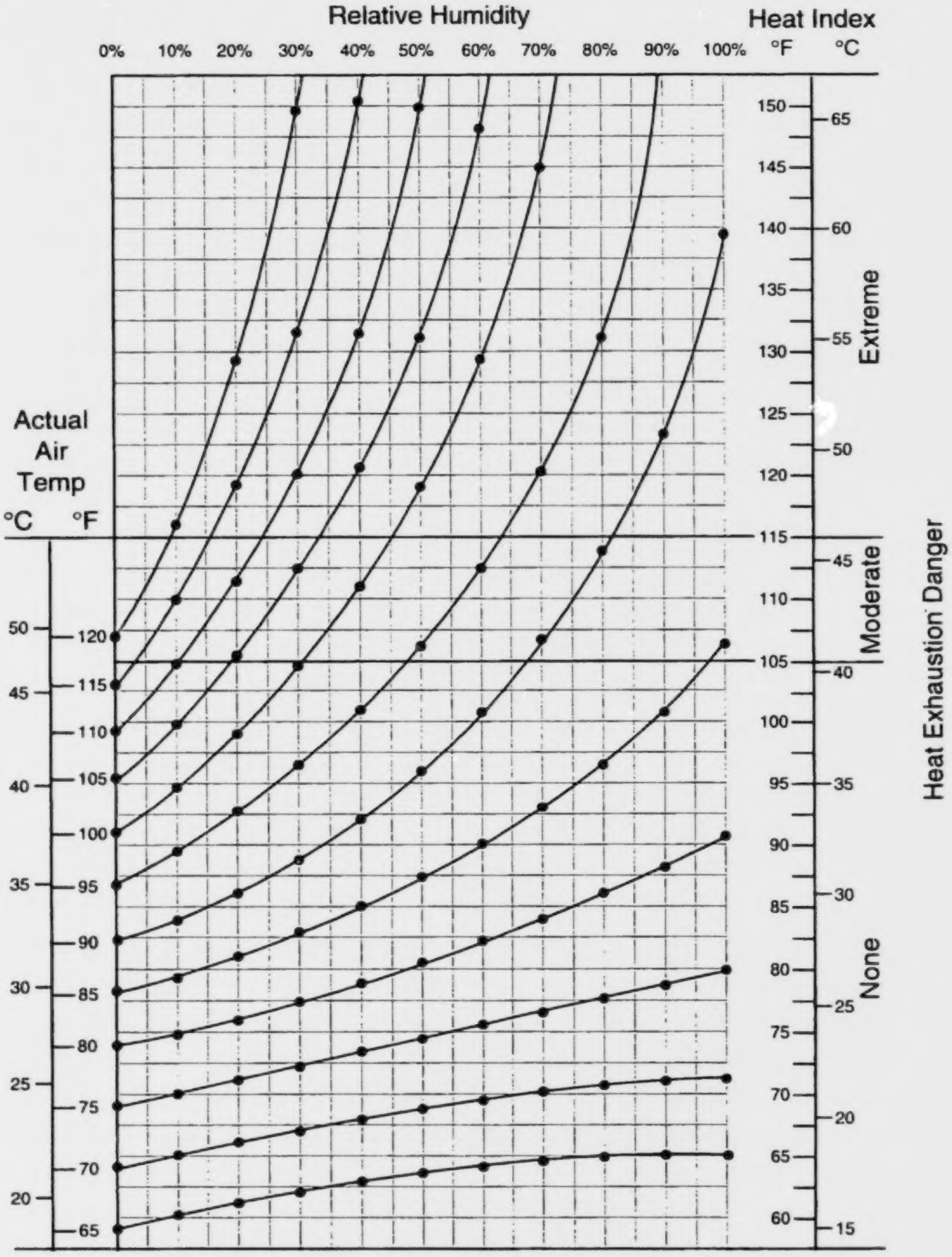

Figure SP 5.2.2B Heat index chart

Name________________________

Date________________________

DASH

STUDENT PAGE 5.2.3 WEATHER AND ITS PREDICTION

1. Trace a weather map on the space below and follow the movement of weather patterns from the last week across it.

2. List the things that seem to determine the movement of weather patterns.

____

____

____

____

____

Name ____________________

Rules of Thumb for Predicting Weather over the Continental United States

A STORM MAY BE COMING

1. There is a ring around the moon.
2. Cumulus clouds begin to change to cumulonimbus clouds.
3. High cirrus clouds are followed by thickening stratus clouds.
4. The western sky is dark and stormy.
5. The barometer steadily drops. The possibility of a storm increases when a drop in the barometer is accompanied by conditions 1 though 4.
6. A wind from the north changes to one from the south.

WEATHER IS CLEARING

1. Barometer readings begin to rise.
2. Winds start to come from the west.

WEATHER WILL REMAIN CLEAR

1. The sky is clear or there are numerous cumulus clouds.
2. The wind comes from the west or from the northwest.
3. The barometer stays steady.

Name__________________________

Date___________________________

DASH

STUDENT PAGE 5.2.4 CLOUDS AND FRONTS

1. Use the table below to follow the sequence of cloud types when *cold fronts* are predicted to pass through the area.

DATE/TIME	TYPE OF CLOUD	WIND DIRECTION	TEMPERATURE	BAROMETRIC PRESSURE

Name ____________________

2. **Use the table below to follow the sequence of cloud types when *warm fronts* are predicted to pass through the area.**

DATE/TIME	TYPE OF CLOUD	WIND DIRECTION	TEMPERATURE	BAROMETRIC PRESSURE

Name ____________________

3. How do temperature and pressure seem to be related in the passage of fronts?

____

____

____

____

____

____

4. Describe the sequence of events in the passage of a *cold* front.

____

____

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____

____

4. Describe the sequence of events in the passage of a *warm* front.

____

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Name________________________

Date________________________

DASH

STUDENT PAGE 5.2.5 TRIANGLES

1. How do we measure angles?

____

____

____

2. What is a right angle?

____

____

3. What kind of angle is made when two 90° angles are put back to back? ________

4. What do we mean when we say that the sides of notebook paper are parallel?

____

____

____

5. What is your working definition of a right triangle?

____

____

____

6. What is your working definition of parallel lines?

____

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____

Name ______________________________

7. Record how you labeled the triangles made by the diagonal fold on a piece of notebook paper.

a) List the angles that are equal.

b) What is the sum of Angle B and Angle C in degrees? __________

c) What is the sum of Angle B and Angle F in degrees? __________

d) What is the sum of the angle of the triangle made by Angle A, Angle B, and Angle F? ________

e) What is the sum of the angles of the triangle made by Angle C, Angle D, and Angle E? ________

8. What are congruent triangles?

____

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____

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9. How can you test to see whether triangles are congruent?

____

____

____

Name ______________________

10. What are similar triangles?

____

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11. How can you test to see whether triangles are similar?

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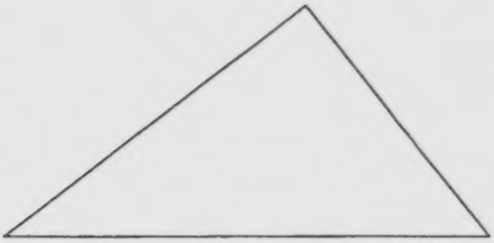
____

____

12. How did you make smaller similar triangles by making folds on a larger triangle?



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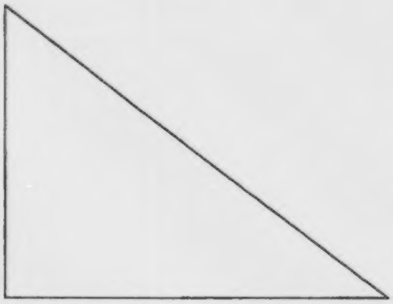
13. Record how you folded a triangle to show that the sum of the angles is 180°?



Name ______________________________

14. Draw a rectangle on the parallel lines below with two of its sides made by the parallel lines. Draw a diagonal from opposite corners.

15. On the rectangle with a diagonal in Item 14 label the angles of the two largest triangles (A–F). On the similar smaller triangles label the angles that correspond to Angles A–F in the same way.

16. List the angles that are equal to each other.

17. When two straight lines cross each other, what can we say about angles that are opposite each other?

Name____________________________

Date_____________________________

DASH

STUDENT PAGE 5.2.6 GNOMON

1. Construct a gnomon and invent a way to make sure that it always has the same orientation. Draw your gnomon and describe how you oriented it.

2. What does the gnomon-shadow line tell us about the path of the sun during the year?

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Name ______________________________

3. **In the table below, record the height of the North Star above the northern horizon.**

DATE	DEGREES		DATE	DEGREES

DASH

Name__________________________

Date___________________________

STUDENT PAGE 5.2.7 SIZE OF EARTH

Describe how you found the circumference of Earth. Use a diagram if needed.

Name________________________

Date________________________

STUDENT PAGE 5.2.8 MOON THROUGH A TELESCOPE

1. **Draw the moon as you see it through a telescope or opera or field glasses. Record the place where observations were made, the moon phase, and the date of your observation. Label identifiable features on your drawings.**

PLACE:	**PLACE:**	**PLACE:**
DATE:	**DATE:**	**DATE:**
MOON PHASE:	**MOON PHASE:**	**MOON PHASE:**

PLACE:	**PLACE:**	**PLACE:**
DATE:	**DATE:**	**DATE:**
MOON PHASE:	**MOON PHASE:**	**MOON PHASE:**

Figure SP 5.2.8(1) Diagrams of the moon as seen through a telescope or field or opera glasses

Name ______________________________

2. Compare your diagrams with the view of the two sides of the moon shown in Figure SP 5.2.8(2). What part of the moon did you see?

3. On each of the circles representing the moon in Figure SP 5.2.8(3), shade the night side (the side not lighted by the sun). Draw an arrow from the center of the moon to the middle of the surface facing Earth. Follow your teacher's instructions to determine whether the moon turns on its axis.

4. Explain how Figure SP 5.2.8(3) can be used to show when the far side of the moon receives sunlight.

5. Explain what Figure SP 5.2.8(3) tells us about the rotation of the moon.

6. Explain what Figure SP 5.2.8(3) tells us about the length of a moon day and a moon night.

ILLUSTRATIONS

Name ______________________________

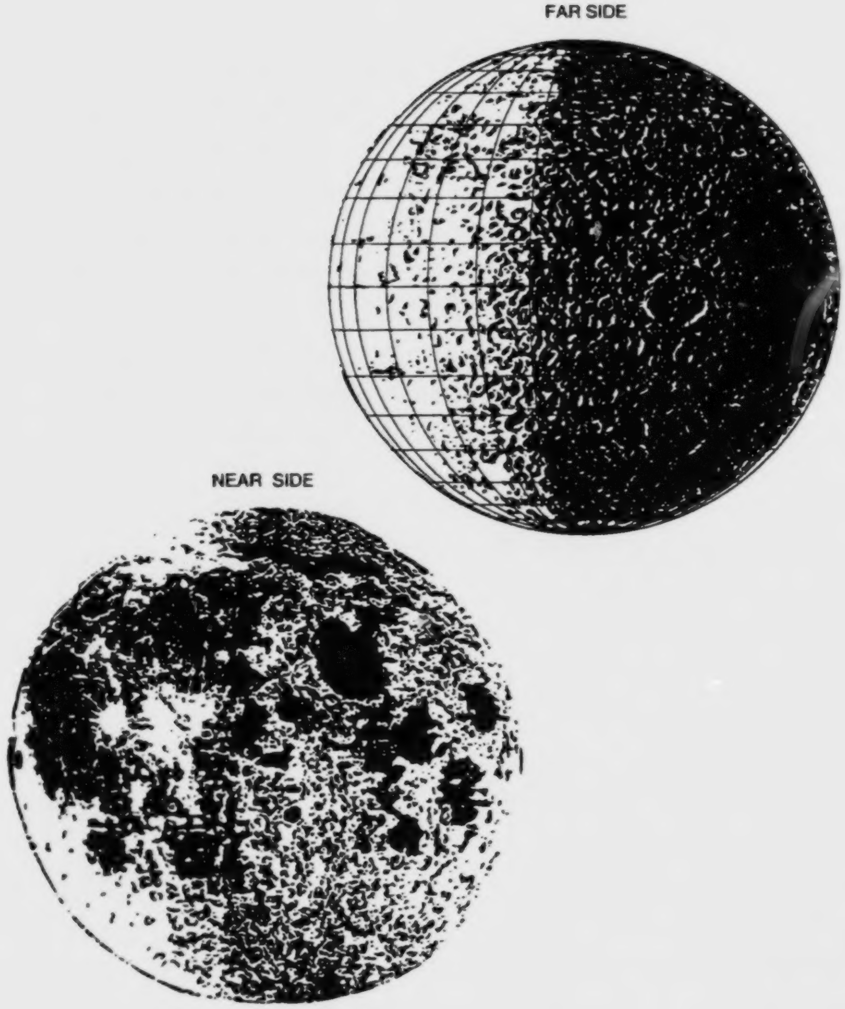

FAR SIDE
NEAR SIDE

Figure SP 5.2.8(2) The two sides of the moon

BEST COPY AVAILABLE

Name ______________________________

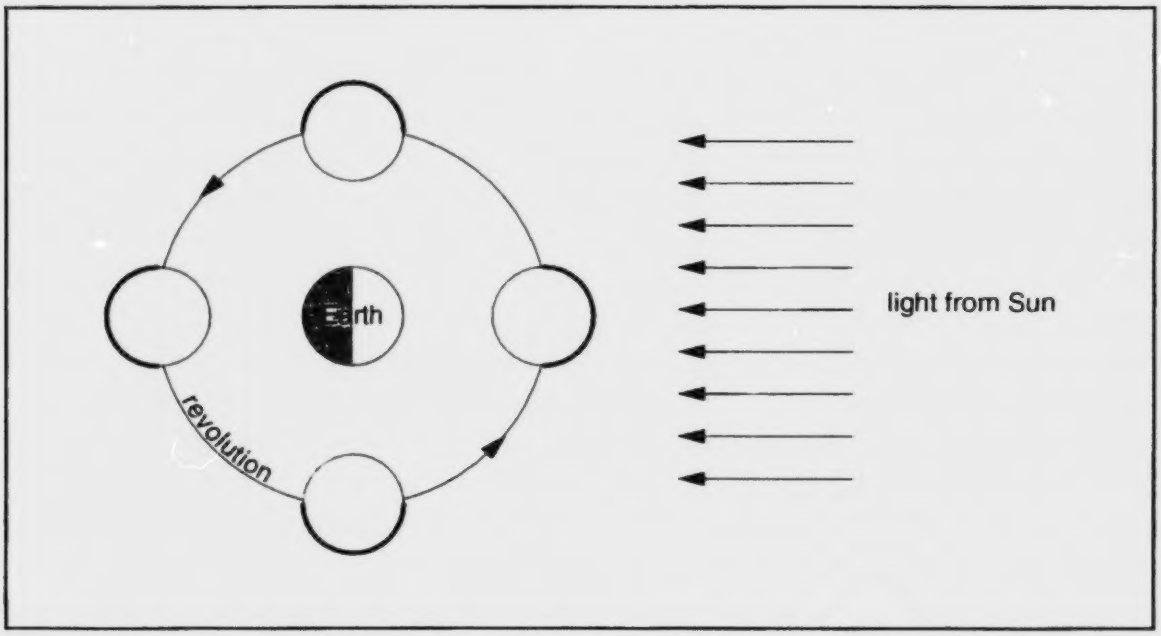

Earth
revolution
light from Sun

Figure SP 5.2.8(3) The moon's passage around Earth.

Name______________________

Date______________________

STUDENT PAGE 5.2.9A
HISTORY OF MEASUREMENT OF THE MOON

Trying to determine the distance from Earth to the moon was a wonderful mathematical game played by many ancient astronomers. The Greeks and Romans made observations that gave them distances ranging from Aristarchus's 12,000 miles to Hipparchus's 280,000 miles. These astronomers used the same method that we use to measure the height of trees—triangulation.

Problem of Finding Angles

Ancient astronomers knew how to measure the distance to the moon, but there was a problem. It is difficult to make angle measurements involving faraway objects, and they had to make their determinations using only the naked eye and very crude equipment. The invention of the telescope made the work much more exact.

Problems of Distance and Time

Because the moon is so far away, observers had to be far apart so that the angles would be large enough to make good calculations. This became possible when explorers began to travel to different parts of Earth. One problem remained, the observations had to be made at the same time. This problem was solved by having both measurements made when an occultation took place. An *occultation* is the eclipsing or passing of one celestial body in front of another, for example, when a planet passes in front of a star. Since it happens so far away, an occultation can be seen at almost exactly the same time in different parts of Earth. An occultation is a heavenly timer.

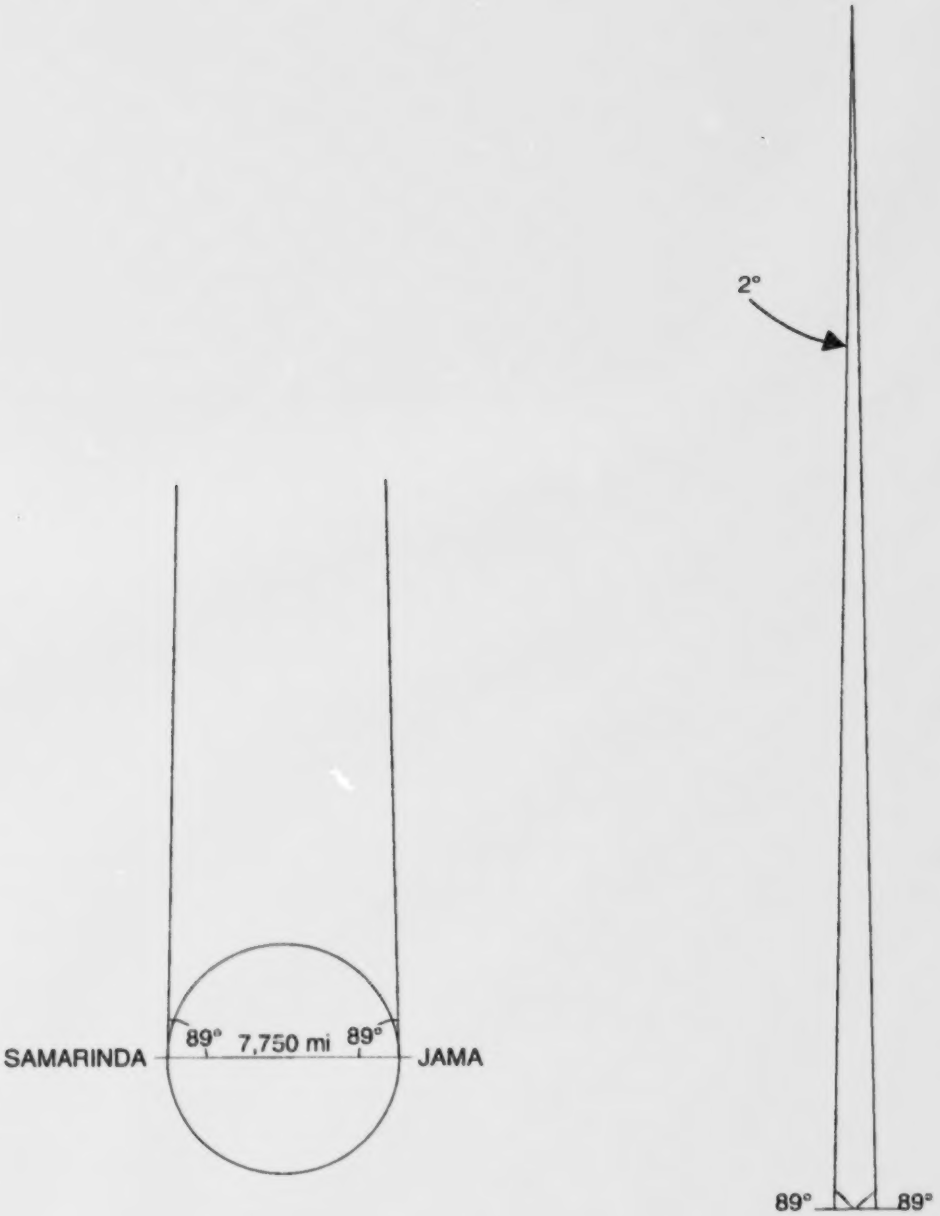
Name ____________________________

Data

Some data will help us determine the distance to the moon. Let's say that two astronomers focus on the same spot on the moon at the moment that Mars occludes Spica. One is in Jama, Ecuador, which is just about on the equator at 81° W longitude. The other is in Samarinda, Borneo, which is just about on the equator at 118° E longitude. Each observer measures the angle of the moon in relation to an imaginary line that runs straight through Earth and joins the two locations. The angle made by the imaginary line to the spot on the moon and the imaginary line joining the observers is 89°. The length of the imaginary line joining the observers is approximately 7,750 miles or 12,740 km. See Figure SP 5.2.9A.

ILLUSTRATION

Name ______________________________


2°
89°
7,750 mi
89°
SAMARINDA
JAMA
89°
89°

Drawing of
a triangle with
base angles
of 89°

Figure SP 5.2.9A Diagram showing measurement of angles at Samarinda, Borneo, and Jama, Ecuador, and the distance between these sites.

Name__________________________

Date___________________________

STUDENT PAGE 5.2.9B
HOW BIG AND FAR AWAY IS THE MOON?

1. Use the data on the determination of the distance from Earth to the moon found in Student Page 5.2.9A HISTORY OF MEASUREMENT OF THE MOON. Explain how you made your calculations. Use diagrams as needed.

Name ______________________________

2. Explain how you made your determination of the diameter of the moon. Use diagrams as needed.

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DASH

Name________________________

Date________________________

STUDENT PAGE 5.2.10 PATHS OF CELESTIAL BODIES

1. Describe how a camera can be set to make a continuous photograph of the movement of the stars through the night. Use diagrams if needed.

2. How did you choose the site used for photographing?

3. What did you predict the photo would look like? Was your prediction verified?

Name ______________________

4. **Explain what the photo tells us about the stars and planets. Use diagrams if needed.**

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DASH

Name________________________

Date________________________

STUDENT PAGE 5.2.11A
MODELS OF EARTH, SUN, PLANETS, AND STARS

1. List the things you know about Earth and its relationship to other heavenly bodies.

____

____

____

____

____

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____

2. Create a model to show the movement of the moon, sun, planets and stars as they move in the heavens throughout the day and night over the year. Draw your model below.

Name ______________________________

3. **Read the account of Ptolemy's model of the universe. See Student Page 5.2.11B PTOLEMAIC AND COPERNICAN MODELS. Compare your model with Ptolemy's. Are there things that Ptolemy's model accounts for that your model does not include? If so, list them.**

4. **Read the account of Copernicus model of the universe in Student Pages 5.2.11B PTOLEMAIC AND COPERNICAN MODELS. Compare your model with Copernicus's. Are there things that Copernicus accounted for that your model does not include? If so, list them.**

Name ______________________________

5. Compare Ptolemy's model with Copernicus's. List any differences.

6. Which of the models seemed the most reasonable when members of the class represented the heavenly bodies? Explain your reasoning.

7. According to the Ptolemaic, the Copernican, and class models what would happen to a rocket shot toward Mars?

Name ________________________________

8. How do the data in the Tables SP 5.2.11A-1 and 3 support any or all of the different models you have used?

9. Of the three models, which is the most believable? Explain your thinking.

Name ______________________________

Table SP 5.2.11A-1 Data implied by the Ptolemaic model

BODY	CIRCUMFERENCE OF ORBIT	REVOLUTION AROUND EARTH	ORBITAL SPEED AROUND EARTH
Earth	—	—	—
Mercury	223,000,000 mi	1 day 86,400 sec	223,000,000 mi/day 2,600 mi/sec
Venus	415,000,000 mi	1 day 86,400 sec	415,000,000 mi/day 4,800 mi/sec
Sun	580,000,000 mi	1 day 86,400 sec	580,000,000 mi/day 6,700 mi/sec
Mars	874,000,000 mi	1 day 86,400 sec	36,400,000 mi/day 9,700 mi/sec
Jupiter	2,990,000,000 mi	1 day 86,400 sec	2,990,000,000 mi/day 35,000 mi/sec
Saturn	5,600,000,000 mi	1 day 86,400 sec	5,600,000,000 mi/day 65,000 mi/sec
Nearest Star	26,400,000,000,000 mi	1 day 86,400 sec	26,400,000,000,000 mi/day 306,000,000 mi/sec

Note: Approximate numbers

Table SP 5.2.11A-2 Data implied by the Copernican model

BODY	CIRCUMFERENCE OF ORBIT	REVOLUTION AROUND THE SUN	ORBITAL SPEED AROUND THE SUN
Sun	—	—	—
Mercury	223,000,000 mi	88 days 7,600,000 sec	2,530,000 mi/day 29 mi/sec
Venus	415,000,000 mi	224 days 19,400,000 sec	1,850,000 mi/day 21 mi/sec
Earth	580,000,000 mi	365 days 31,500,000 sec	1,590,000 mi/day 18 mi/sec
Mars	874,000,000 mi	687 days 59,400,000 sec	1,270,000 mi/day 15 mi/sec
Jupiter	2,990,000,000 mi	4380 days 378,000,000 sec	683,000 mi/day 8 mi/sec
Saturn	5,600,000,000 mi	10,900 days 945,000,000 sec	511,000 mi/day 6 mi/sec
Nearest Star	—	—	—

Note: Approximate numbers

Name ______________________________

Table SP 5.2.11A-3
Currently known distances from Earth

BODY	DISTANCE FROM EARTH IN MILLIONS OF MILES
Moon	0.24
Sun	93
Mercury	50 to 136
Venus	25 to 161
Mars	35 to 248
Jupiter	367 to 600
Saturn	744 to 1,028
Uranus	1,606 to 1,960
Neptune	2,677 to 2,910
Pluto	2,570 to 4,700

Note: Approximate numbers

Table SP 5.2.11A-4
Currently known data about the heavenly bodies

BODY	AVERAGE DISTANCE FROM SUN IN MILES	REVOLUTION AROUND THE SUN	ROTATION TIME	DIAMETER IN MILES
Sun	—	—	26 days	864,000
Mercury	36,000,000	88 days	59 days	3,025
Venus	67,000,000	224 days	244 days	7,526
Earth	93,000,000	365 days	1 day	7,927
Mars	141,000,000	687 days	1 day	4,218
Jupiter	483,000,000	12 years	10 hr	88,700
Saturn	886,000,000	29.5 years	10 hr	75,100
Uranus	1,780,000,000	84 years	22 hr	32,000
Neptune	2,790,000,000	164 years	23 hr	31,000
Pluto	3,660,000,000	248 years	6.4 days	2,500
Nearest Star	2,640,000,000,000	—	unknown	unknown
BODY	**AVERAGE DISTANCE FROM EARTH IN MILES**	**REVOLUTION AROUND EARTH**	**ROTATION TIME**	**DIAMETER IN MILES**
Moon	238,000	28 days	28 days	2,160

Note: Approximate numbers

DASH

Name________________________

Date________________________

STUDENT PAGE 5.2.11B
PTOLEMAIC AND COPERNICAN MODELS

PTOLEMY

Some eighteen hundred years ago there lived in the seaport city of Alexandria, Egypt, the astronomer Claudius Ptolemaeus whom we now call Ptolemy. He invented an Earth-centered model of the heavens showing the movement of the stars, planets, moon, sun, and Earth that was used by astronomers until very recent times

Ptolemy had no telescopes. Using what he saw and could reason, he concluded that because Earth is so large compared to the bodies seen in the heavens, it does not move. From observations of the moving bodies in the heavens he gave them all orbits or pathways that passed around Earth. The planets that Ptolemy knew were Mercury, Venus, Mars, Jupiter, and Saturn. He said the orbits of the planets, sun, and moon all were on a plane or flat surface because they follow the same path (the ecliptic) across the sky.

In addition to their daily passage about Earth, the planets regularly move back and forth against the background stars. To account for this Ptolemy said they must travel in circles as they orbit Earth. These circles he called *epicycles*. He explained that Mercury and Venus are seen only in the morning and evening because of their movement in epicycles in front of the sun.

He reasoned that the moon and the planets all occluded (passed in front of) the stars; therefore, the stars must be the farthest away from Earth. The relative distance of the moon and planets he determined by the time that it takes them to go through their cycles.

Name ______________________

The moon goes through its cycle from new to full and back to new in about 29-1/2 days. Mercury goes from its first appearance on the morning side of the sun to the night side and back to the morning side in 88 days. Venus goes through the same cycle in 224 days.

For the cycle of the sun and the other planets he used the time it takes them to travel through the Zodiacal Band. It takes the sun 365 days, Mars 685 days, Jupiter 12 years, and Saturn 30 years. His order, then, of relative distance from Earth was the moon nearest, then Mercury, Venus, the Sun, Mars, Jupiter, and Saturn. His model looked like Figure SP 5.2.11B(1).

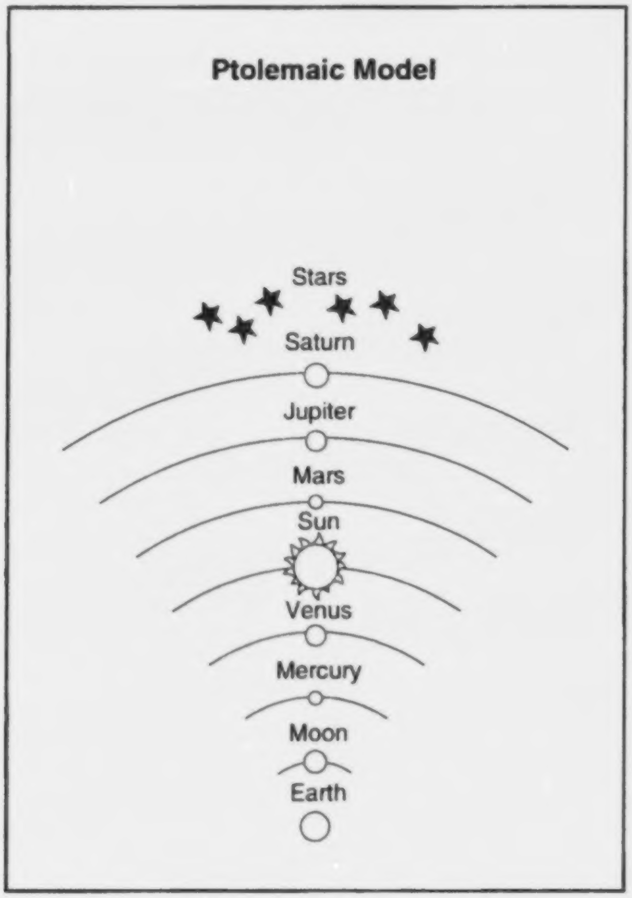

Figure SP 5.2.11B(1) Ptolemy's model of the moon, planets, sun, stars, and Earth

4.14

Name ____________________________

COPERNICUS

Nicolaus Copernicus was born in Poland in 1473. He studied mathematics and astronomy and earned doctoral degrees in church law and medicine. Though he worked as an administrator of the Catholic church and as a medical doctor, his great love was astronomy. He knew the solar system model of Ptolemy well.

At the time Copernicus lived, navigators were attempting to use Ptolemy's system to predict eclipses of the planets and stars to help them find their longitude or how far west or east they were from their home ports. The predictions were often found to be too far off to be very helpful. Rather than try to repair Ptolemy's work, Copernicus said the logic for the model was wrong, so he set about devising a sun-centered model.

Copernicus started his work on his idea of the solar system in 1506. For the next 35 years he labored and received the first copy of the book in which he reported his model a few hours before his death in 1543. He titled his book *Revolutions of Heavenly Spheres*.

His model looked like the one shown in Figure SP 5.2.11B(2). Note that the sun is in the center and all the planets revolve about it. As in Ptolemy's model, the sun, planets, moon and Earth are drawn on the plane of the ecliptic. The stars do not move, and the apparent daily movement of the heavens is due to the turning of Earth on its axis and Earth's traveling around the sun.

Name ______________________________

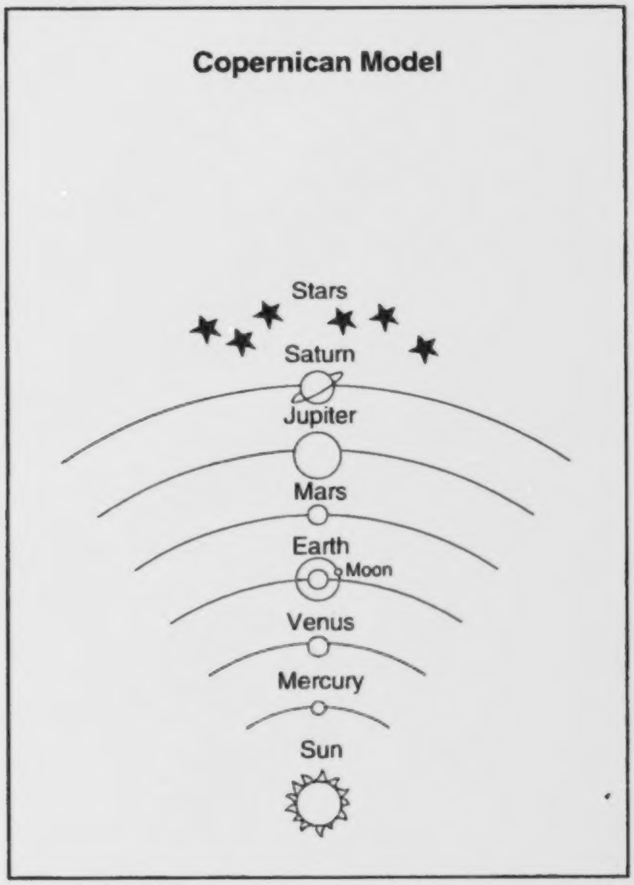
Copernican Model
Stars
Saturn
Jupiter
Mars
Earth
Moon
Venus
Mercury
Sun

Figure SP 5.2.11B(2) Copernicus's model of the moon, planets, sun, stars, and Earth

DASH

GRADE FIVE
CLUSTER 3

Animals

5.3.1 Pet Care
5.3.2 Bird Feeder
5.3.3 Birds I Know
5.3.4 Cells
5.3.5 Cell Quiz
5.3.6 Male Urogenital System
5.3.7 Female Urogenital System
5.3.8 Ovulation Cycle
5.3.9 Ovulation and Pregnancy
5.3.10 Embryology
5.3.11 Body Changes
5.3.12 Bones
5.3.13 Skeletal System
5.3.14 Muscles
5.3.15 Muscular System
5.3.16 Chemistry and Bones
5.3.17 The Senses
5.3.18 The Eye
5.3.19 Sound
5.3.20 The Ear

ACTIVITY 5.3.1 PET CARE

OBJECTIVES

The students
- Take responsibility for the care of their classroom animal.

BACKGROUND

DASH students have been taking care of classroom pets since kindergarten. However, it is good practice to review responsibilities and procedures before animals are introduced. This activity should precede introduction of any animal to the classroom.

Responsibility

If the students have not had animals in the classroom before, have them research their animals' needs. Information can be gotten from pet stores, reference books, and friends who have previously taken care of animals.

When to Use the Activity.

Though there is no particular class pet suggested for DASH 5, there may be times when students will want to bring animals to the classroom, particularly birds. Under these circumstances review the content of PET CARE.

STUDENT ROLES

Farmer
Animal breeder
Pet owner

MATERIALS

caging materials as needed
pet food as needed
Student Page 5.3.1 PET CARE

PRODUCTS

Well-cared-for animals
Responsibility Chart
Completed Student Pages

PROCEDURES

1. **Introduce the responsibilities that go with caring for a classroom pet. Indicate that we must set up a Pet Responsibility Chart.**

   Help the students include such things as
   - Water.
   - Food.
   - Ventilation or aeration.
   - Proper temperature.
   - Various special needs of nesting, gnawing, grinding (for birds), and so forth.
   - Sanitation.

2. **Discuss how to handle the pet.**

   Include
   - Any requirements for gloves.
   - How to catch the animal.
   - Where and how to hold it.

3. **Have the students share their knowledge. When possible, have experienced animal caretakers work on teams with their inexperienced peers.**

EXTENSION

- Have the students report on how pet stores or zoos care for their animals.

DASH

Name________________________

Date________________________

STUDENT PAGE 5.3.1 PET CARE

Describe what must be done to care for your pet animal.

ACTIVITY 5.3.2 BIRD FEEDER

OBJECTIVES

The students
- Observe birds in their environment.
- Develop questions about birds they wish to answer.
- Carry out their research and report on it.

BACKGROUND

This activity is a continuation of studies begun in DASH 4. It should be followed by Activity 5.3.3 BIRDS I KNOW. In BIRD FEEDER the students develop their own questions that can be answered by bird watching. By the fifth grade students have reached a point where they can form and research their own questions. Their informational resources may include bird watchers they know, pet store owners, magazines, and books. They should be strongly urged to use such resources.

Observation Records

Records of observations should be kept in an orderly way. It is best if a book or pages in a notebook be set aside to keep records. Most observations will need to show the following:
- date
- time of observation
- general weather conditions
- description of special conditions such as environmental surroundings, the presence or absence of people and other animals, and so forth

Reports of Research

Reports can be as formal as seems reasonable. They should include such things as these:
- a statement of the questions being asked
- how the study was carried out
- data displayed in graphs or in some other concise form
- some conclusion that draws together the data collected and responds to the question originally asked

Food

Food for the feeder can be expensive. The following suggestions can result in some exciting investigations and reduce the expense:

- Gather weed seeds in the fall and spring and dry them.
- Get a grain that is relatively inexpensive and break it up to serve the needs of different kinds of birds if necessary. Dried corn, wheat, barley, and rice can be used.
- Use the scraps from the cafeteria such as bread, fruits, and meat and test them to see what the birds will eat. The feeder will have to be cleaned regularly to keep uneaten material from decomposing. Excess food can often be put in the DASH 3 compost pile.

STUDENT ROLE

Ornithologist

MATERIALS

hammers
nails
wood
bird food
2-liter bottles to make transparent feeders for small birds
Student Page 5.3.1 BIRD FEEDER

PRODUCTS

Completed Student Pages

PROCEDURES

1. **Review what the students discovered about birds in the fourth grade. Have them refer to the observations recorded in their Science Record Books.**

   Ask such questions as these:
   - Did the same birds come to the feeder all year long?
   - If the population changed, how did it change?
   - How did you identify the birds?
   - Did any certain kinds of birds leave for a period of time and then return?
   - Did the same birds leave and come back?
   - How did you identify the birds?

- What foods do different birds prefer?
- Did you arrange to feed small and large birds separately? If so, how?
- How long did it take to get the birds to use the feeder?
- How did you get the birds to use the feeder?
- Were any of the birds that came to the feeder crippled?
- How did the crippled birds interact with the other birds?

2. **Explain that we are going to again feed birds and this year we are going to develop a set of questions we will try to answer during the year. Have the students work alone or in small groups to come up with their own research questions and plans for investigation.**

   Help the students by asking such questions as these:
   - Do the same kind of birds visit the feeder as last year? Was the mix of kinds of birds the same throughout the year?
   - Are there certain kinds of birds that do not eat at the feeder? Can those birds that don't normally use the feeder be encouraged to eat with other arrangements. If so, what other arrangements might work?
   - What happens to the population of birds as we change the food available?
   - How do the birds respond to changes in seasons? (Migrate, change coats, get fatter or thinner, and so forth.)
   - How wide a variety of foods will specific kinds of birds eat?
   - What happens to crippled birds?
   - What are the social habits of birds at the feeder?
   - Can you train the birds to do something before they get food?
   - What do birds eat besides seed?
   - What do birds prefer to eat?
   - Can feeding birds be attracted to nesting boxes?
   - What other questions can we seek answers to? (If you have reports from the previous year, some students may want to extend their earlier research.)

3. **Have the students state the questions they wish to investigate and draw up plans for their study. Have them report their plans and have the other students act as research colleagues making suggestions for improvement.**

Help the students consider such things as these:

- When observations should be made—time of year, time of day, weekends.
- If observations are to be made outside school, when and how they are to be made.
- How conflicts in needs of different groups for materials can be resolved.
- Where feeders are to be placed.
- How records are to be kept.
- Special equipment that will be needed—telescopes, special feeders, and so forth.

4. **Have the students make their bird feeders. Remind students that they can make plastic "see into" feeders that allow only small birds to enter.**

5. **Have the students periodically report on the progress of their investigations. Encourage them throughout the study to read about their questions and ask others to share what they are seeing and investigating.**

6. **Have the students write a final report and make a presentation to the class.**

EXTENSIONS

Have the students

- Think about the kinds of wild seeds that birds eat and then harvest and dry these seeds for the feeder. (These will include a great variety of grass and weed seed as well as crop seed.)
- Work with an ornithologist to find out how to mark birds for identification.
- Hold an ornithological conference with several classes and report the findings.

DASH

Name________________________

Date________________________

STUDENT PAGE 5.3.2 BIRD FEEDER

1. State your research question.

2. Describe how you intend to carry out the investigation.

3. Describe the data that you will be collecting.

4. Record your data on additional pages.

5. List any conclusions you can draw from your data.

ACTIVITY 5.3.3 BIRDS I KNOW

OBJECTIVES

The students
- Select a local bird to study in detail.

BACKGROUND

This activity is part of a series on bird-watching. It should be preceded by Activity 5.3.2 BIRD FEEDER. In BIRDS I KNOW the students pick one bird to do research on and to watch for particular behavior. Resources can be bird field guides and publications of the Audubon Society or other groups. The intent of this activity is to get students to know one bird well and thereby engender an interest in all birds.

STUDENT ROLE

Ornithologist

MATERIALS

bird field guide.
field glasses (optional)
Student Page 5.3.3 BIRDS I KNOW

PRODUCTS

Completed Student Pages

PROCEDURES

1. **From the birds already identified have the students select one for research and observation.**

2. **Discuss what the students will need to find out about the bird they selected.**

Help them include such things as

- Description. (Have the students take photos or draw pictures.)
- Range. (Where and when the bird is found in different parts of its habitat.)
- Nesting practices, including the way the bird cares for its young.
- Food preferences.
- Interaction with other animals.
- Predatory enemies.
- Economic value, if any, including such things as eating crop-destroying insects and damage to crops and the environment the bird may cause.
- Endangered status, if any.
- Other interesting characteristics.

3. **Have the students observe their bird throughout the school year using Student Page 5.3.3 BIRDS I KNOW to guide their study.**

4. **Have the students report what they have learned about their bird.**

EXTENSION

- Have the students use their reports to assemble a local bird field guide for their school.

DASH

Name________________________

Date________________________

STUDENT PAGE 5.3.3 BIRDS I KNOW

1. Give the local or scientific name of your bird and any special name you might have given it.

____

____

2. Describe the physical appearance of the bird you selected. Make a drawing of your bird and include photos if you take them.

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Name______________________________

3. Describe the bird's habitat or where it prefers to live.

4. What are your bird's nesting practices? Where does it nest? What kind of nest does it make? How does it care for its young?

5. What foods does your bird like to eat?

6. How does your bird interact with other birds and other kinds of animals?

Name________________________________

7. List your bird's predatory enemies, if any.

8. Do birds like yours have any economic value? Explain your answer.

9. Is your bird on the list of endangered birds? If so, how many of its species are left?

10. Tell about the special characteristics of your bird.

ACTIVITY 5.3.4 CELLS

OBJECTIVES

The students
- Develop a concept map of the term cell.
- Use a microscope.
- Make microscope slides.
- Observe cells under a microscope.
- Determine the number of cells in a millimeter of tissue.

BACKGROUND

This activity introduces the concept of the cell. It should follow Activity 5.3.10 EMBRYOLOGY which should be started at the first of the school year to get through the development of a nine-month pregnancy. After making a concept map the students proceed to use a microscope to view cells and identify their basic structures in onion tissue. In the tissue are cells. These cells have cell walls, cytoplasm or grainy matter inside, and nuclei seen as large dots in the cytoplasm. The students then determine how many cells there would be in a chain 1 mm long and calculate how many there would be in a square millimeter ($mm^{2)}$ and a cubic millimeter ($mm^{3)}$.

This activity should be preceded by Activity 5.10.7 MAKING A MICROSCOPE. Where possible, have the students use equipment they have made themselves. If greater magnification is desired, they can use a commercial microscopes.

Commercial Microscopes

If the students use commercial microscopes, they will need to be instructed in handling them. Include the following instruction:
- Carry the microscope with one hand grasping the arm (the vertical support) and one supporting the base.
- Start observation with the lowest-power objective lens (the shortest lens).
- Bring the lens as close to the slide as possible without touching it.
- Focus upward using the coarse adjustment (the largest focusing knob).
- Once the object is visible, refine the focus with the fine adjustment (the small focusing knob).
- Follow the same procedures with the stronger objective lenses.

Iodine Stain

A satisfactory iodine stain can be made by diluting a medicinal iodine solution. Add 9 mL of water to 1 mL of iodine solution. Dispense the solution with eyedroppers or straws.

STUDENT ROLES

Cytologist
Botanist
Zoologist

MATERIALS

microscope
slides or plastic strips from carbonated drink bottles
iodine solution
baby food jars for iodine
eyedroppers or straws.
onion
Student Page 5.3.4 CELLS

PRODUCTS

Slides
Drawings of cells
Completed Student Pages

PROCEDURES

1. **Have the students make a concept map of the term cell.**

   Help them include such things as
   - A room.
   - Rooms in a prison.
   - A dry-cell battery.
   - Small units of living things.
   - Something seen under magnification.
   - Things our bodies are made of.

2. **Introduce the students to the microscopes they will be using.**

   Discuss
   - Handling.
   - Adjusting the lenses.
   - Adjusting light.
   - Cleaning.

3. **Have the students observe air bubbles on a slide.**

   Have them
   - Put a drop of water on a flat transparent surface. (This can be a glass or plastic slide.)
   - Place a thin glass or plastic cover over it and observe the water alone.
   - Report what they see. (Air bubbles will be seen most frequently. Thin, curved dark-lined circles of different sizes will probably be observed. Identify these as bubbles.)

4. **Have the students prepare a slide of a thin layer of onion tissue for viewing cells.**

   Have them
   - Place a very thin piece of onion tissue in a drop of water and tease it with a paper clip or other probe to flatten it out.
   - Place a thin glass or plastic cover over the tissue.
   - View the tissue in bright light and report what they see. (The first things that may be taken for cells will probably be thin, curved, dark-lined circles of different sizes. Identify these as air bubbles. Review what the students saw when they looked at water alone.)
   - Stain the tissue by putting a drop of iodine solution at the edge of the cover so that it contacts the water. (The stain will be drawn in by the water and color the onion. If the students are impatient, have them remove the cover and put the stain directly on the tissue.)
   - View the tissue again and report what is seen.
   - Draw a diagram of what they think might be cells.

5. **Summarize the observations of the onion tissue with the students' diagrams laid out on a table. Have a microscope and tissue sample handy to verify findings.**

Ask such questions as these:

- How could we describe the cells? (Get at such ideas as they look like boxes with rounded corners with something inside, like rooms, like a wall of bricks, like jail cells.)
- How do the cells differ from air bubbles? (Work to such ideas as the air bubbles are much rounder and appear empty, air bubbles come in different sizes, but the cells in the tissue are about the same size.)
- What did we see in the cells? (Probe for such answers as a thick wall on the outside, a dot near the middle (the nucleus), other tinier dots or grains within the cells.)
- What can we say about the comparative size of the cells we saw? (Work to the idea that they were about the same size.)

6. **Have the students study a root tip from a piece of grass or a freshly germinated seed such as a radish seed.**

Have them

- Put a drop of water on a flat transparent surface. (This can be a glass or plastic slide.)
- Cut off a root tip with some root hairs and put it in the water drop.
- Put a cover over the root tip and water.
- Wrap the slide in paper and gently press on the cover to crush the root tip. (The paper prevents any glass or plastic shards from cutting the student.)
- Have the students look at the crushed root tip and report what they see.
- Stain the root by putting a drop of iodine solution at the edge of the cover so that it contacts the water. (Again the stain will be drawn in by the water and stain the root tip. If the students are impatient, have them remove the cover and put the stain directly on the root.)
- View the root again and report what they see.
- Draw a diagram of what they see.

7. **Summarize the observation of the root with the students' diagrams laid out on a table. Have a microscope and root samples handy to verify findings.**

Ask such questions as these:

- How could we describe these cells? (Get at such ideas as they look something like the cells of the onion tissue, like boxes with rounded corners but more irregular and of different sizes.)
- What did we see in these cells? (Probe again for such things as a thick wall on the outside, a dot near the middle, other dots.)

8. Have the students look for cells in plants. Have them draw what they see and keep their slides.

Have them look at thin samples of such things as

- Leaves.
- Petals.
- Pollen.
- Wood shavings.
- Pond-water algae.

9. Have students look for cells in animals and draw what they see.

Have them look for cells in such things as

- Wings of insects.
- Hair.
- Animals in pond water.

10. Have the students determine the size of an onion cell.

Have them

- Make two narrow lines 1 mm apart on a piece of paper smaller than a postage stamp.
- Place the paper under a region on their onion tissue slide that gives a good view of the surface of cells. Both the lines and the cells should be seen in the field of the microscope at the same time.
- Count the number of cells needed to make a chain 1 mm long when placed end to end.
- Have the students calculate the number of cells that would be in a surface 1 mm x 1 mm. (Help them see that the number of cells in a surface would be the square of the length.)
- Have the students calculate the number of cells that would be in a cube 1 mm x 1 mm x 1 mm. (Help them see that the number in a cube would be the cube of the length.)

EXTENSIONS

Set up a microscope center and have the students
- Create a set of slides of things they wish to view.
- Draw what they see and make a book of drawings keyed to the slides.

DASH

Name________________________

Date________________________

STUDENT PAGE 5.3.4 CELLS

1. Draw a small section of onion tissue showing the cells you observed.

2. Describe the cells you have observed.

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____

3. Describe how the onion cell compared with the cells in a root tip.

____

____

____

____

4. Draw and label other kinds of cells you have observed.

ACTIVITY 5.3.5 CELL QUIZ

OBJECTIVE

The students

- Take a cell quiz and discuss the answers.

BACKGROUND

This is one of the activities in the cell series. It was designed to follow Activity 5.3.4 CELLS and precede Activities 5.3.6 MALE UROGENITAL SYSTEM, 5.3.7 FEMALE UROGENITAL SYSTEM, 5.3.8 OVULATION CYCLE, 5.3.9 OVULATION AND PREGNANCY, and 5.5.2 NUTRIENTS AND CELLS.

This is an information-giving quiz structured to find out what the students know. It is suggested that the students be given the quiz and that the quiz be immediately followed with discussion of the answers. Because it is long, the quiz can also answered in sections.

STUDENT ROLE

Informed layperson

MATERIALS

Student Page 5.3.5 CELL QUIZ

PRODUCTS

Completed Student Pages

PROCEDURES

1. **Introduce the CELL QUIZ by having the students use *their own background* to answer the questions about cells found in Student Page 5.3.5 CELL QUIZ. Read the questions aloud so that there is no air of testing. Clarify any questions the students might ask.**

2. **Discuss the quiz.**

CELL QUIZ

1.	Scientists who study cells are called *cytologists*. True False	1.	**True**. *Cytology* is the branch of biology devoted to the study of the cell. Remember a "cellist" plays a cello, not a cell.
2.	Cells are living things. True False	2.	**True**. Cells do all the things that we identify with a living thing. They grow, reproduce, use nutrients for energy and building, and regulate themselves.
3.	Some animals are single-celled. True False	3.	**True**. Single-celled animals have the characteristics of multi-celled animals. They are living organisms that eat other organisms to get needed nutrients. Some examples are the paramecium, the amoeba, and our own white blood cells.
4.	Some plants are single-celled. True False	4.	**True**. Single-celled plants such as simple green algae have the characteristics of multi-celled plants. They are living organisms that can make their own nutrients.
5.	Almost all single-celled plants and animals require a microscope to be seen. True False	5.	**True**. Almost all single-celled organisms are too small to be seen with the unaided eye. Exceptions include giant paramecia.
6.	The animals and plants we normally see are made of many cells. True False	6.	**True**. Almost all the animals and plants we see are multi-celled.
7.	All cells are not the same size. True False	7.	**True**. There is a wide range of sizes in single-celled organisms, the cells that make up tissues, and sex cells.
8.	Cells can be the size of golf balls. True False	8.	**True**. A chicken egg is a single sex cell about the size of a golf ball. An ostrich egg is even larger.

9.	Cells can be so small that it takes 2,000 laid end to end to make a millimeter. True False	9.	**True**. Many bacteria would fit in this range.
10.	Nerve cells that connect our brain with our muscles may have connecting fibers over a meter long. True False	10.	**True**. The nerve cells of the spinal cord can be as long as one and a third meters.
11.	Elephants have nerve cells over 3 meters long. True False	11.	**True**. The nerves of the spinal cord of the elephant are longer than ours in proportion to the length of the body.
12.	Cells are filled with a jelly-like material called *cytoplasm.* True False	12.	**True**. The name of the jelly-like fluid that fills much of the cell comes from the same Greek root from which cytologist comes, *kyto,* meaning container.
13.	The cell's operation is directed by chemical information in it. True False	13.	**True**. The cell is a chemical factory. Chemicals instruct other chemicals how to react. Later the students will find that the master chemical is the DNA of the cell.
14.	Different cells in our body do different things. They have different functions. True False	14.	**True**. The different kinds of cells in our body perform different functions ranging from making digestive juices and oil for our hair to sensing light and carrying messages to our brains.
15.	Groups of cells all doing the same thing are called *tissues.* True False	15.	**True**. Groups of similar cells all doing the same thing are called *tissues,* in part because they often are grouped in sheets. Examples are found in the onion and in our skin, stomach, and coverings of the eye. Even the blood, because it contains countless red and white cells, is called a tissue.

16.	All our body cells must get nutrients from digested food. True False	16.	**True**. The cells of our body rely on other cells to digest food into nutrients. In larger animals, nutrients come to the cells through the bloodstream.
17.	All the cells of our body produce waste. True False	17.	**True**. The cells of our body produce waste as they use nutrients to produce energy, regulate their activity, and build and repair themselves.
18.	All the cells of our body must have oxygen. True False	18.	**True**. The cells of our body require oxygen to produce energy. Energy is produced as the cell converts sugar into water and carbon dioxide.
19.	Most of the cells of our body can reproduce themselves. True False	19.	**True**. One of the characteristics of living things is their ability to reproduce themselves. Cells do this by growing and dividing in half. Some nerve cells and red blood cells are examples of cells that do not divide once they are formed.
20.	In most many-celled organisms a new individual starts with the joining of two cells. True False	20.	**True**. The making of a many-celled organisms requires the joining of two cells called the egg and the sperm. This is the most common way many-celled plants and animals reproduce.
21.	An egg is a single cell. True False	21.	**True**. The egg, no matter how large or small, is a single cell.
22.	Eggs are produced by females. True False	22.	**True**. The egg is the reproductive cell of the female ovary.
23.	Normally eggs are fertilized by sperm before they can develop into new organisms. True False	23.	**True**. Though there are ways of stimulating eggs to divide without fertilization, the normal process involves the joining of egg and sperm.
24.	Males produce sperm. True False	24.	**True**. The sex cells produced by male organisms are called sperm. The male reproductive cell of both plants and animals is the *sperm*.

25.	A human egg and sperm each carry half the chemical information needed to start the development of a baby. True False	25.	**True**. The information for development is recorded in the chemical structure called a *chromosome*. The sperm and egg each have half the number of chromosomes needed for the development of the human embryo.
26.	Human eggs are round and are about 0.25 mm in diameter. True False	26.	**True**. This means that 4 eggs side by side would measure 1 mm.
27.	Human sperm are spear-shaped and are about 0.05 mm long. True False	27.	**True**. The head of the sperm holds chemical information. The tail of the sperm is 10 times as long as the head and is used in swimming to the egg. Note that 20 sperm head to tail would measure 1 mm.
28.	A baby develops from two sex cells that multiply to around one and a half trillion (1,500,000,000,000) cells in nine months. True False	28.	**True**. To get a sense of the size of this number, if placed end to end these cells would make a string about 19,000 km long, or about 5 times the distance from Los Angeles to New York City.
29.	An adult human of average size is made up of about 27 trillion (27,000,000,000) cells. True False	29.	**True**. This would make a string of cells that would stretch around the world about 8 times.
30.	Every day our body throws out 30 million old cells and makes millions of new ones. True False	30.	**True**. Thirty million or more of our body's cells die each day and must be replaced.

EXTENSION

- Administer the quiz again after study of human reproduction.

DASH

Name______________________________

Date______________________________

STUDENT PAGE 5.3.5 CELL QUIZ

Indicate whether you think the following questions are true or false.

1.	Scientists who study cells are called *cytologists.* True False
2.	Cells are living things. True False
3.	Some animals are single-celled. True False
4.	Some plants are single-celled. True False
5.	Almost all single-celled plants and animals require a microscope to be seen. True False
6.	The animals and plants we normally see are made of many cells. True False
7.	All cells are not the same size. True False

Name ______________________

8.	Cells can be the size of golf balls. True False
9.	Cells can be so small that it takes 2,000 laid end to end to make a millimeter. True False
10.	Nerve cells that connect our brain with our muscles may have connecting fibers over a meter long. True False
11.	Elephants have nerve cells over 3 meters long. True False
12.	Cells are filled with a jelly-like material called *cytoplasm.* True False
13.	The cell's operation is directed by chemical information in it. True False
14.	Different cells in our body do different things. They have different functions. True False
15.	Groups of cells all doing the same thing are called *tissues.* True False

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Name ____________________

16.	All our body cells must get nutrients from digested food. True False
17.	All the cells of our body produce waste. True False
18.	All the cells of our body must have oxygen. True False
19.	Most of the cells of our body can reproduce themselves. True False
20.	In most many-celled organisms a new individual starts with the joining of two cells. True False
21.	An egg is a single cell. True False
22.	Eggs are produced by females. True False
23.	Normally eggs are fertilized by sperm before they can develop into new organisms. True False
24.	Males produce sperm. True False

Name ______________________

25.	A human egg and sperm each carry half the chemical information needed to start the development of a baby. True False
26.	Human eggs are round and about 0.25 mm in diameter. True False
27.	Human sperm are spear-shaped and are about 0.05 mm long. True False
28.	A baby develops from two sex cells that multiply to around one and a half trillion (1,500,000,000,000) cells in nine months. True False
29.	An adult human of average size is made up of about 27 trillion cells (27,000,000,000,000). True False
30.	Every day our body throws out 30 million old cells and makes millions of new ones. True False

ACTIVITY 5.3.6 MALE UROGENITAL SYSTEM

OBJECTIVES

The students
- Make a concept map of the term male urogenital system.
- Use a diagram to show the placement of organs in the body cavity.
- Read about the organs of the body.
- Correct their understanding using a human torso.

BACKGROUND

This activity is part of a series dealing with reproduction. It was designed to follow Activities 5.3.4 CELLS and 5.3.5 CELL QUIZ and precede 5.3.7 FEMALE UROGENITAL SYSTEM, 5.3.8 OVULATION CYCLE, 5.3.9 OVULATION AND PREGNANCY, and 5.3.10 EMBRYOLOGY. In MALE UROGENITAL SYSTEM the students are asked to draw upon background gained from handling pet mammals, their investigation of the organs of fish in DASH 4, and other experience. The scientific names of external genitalia will be familiar to most students who have come through DASH.

Community Sensitivity

If yours is a community sensitive about study of human anatomy, you will need to discuss the use of this material with your administration.

Concept Map

The students begin by making a concept map of the term urogenital system of a male. Because this includes both the urinary and reproduction systems, the students may need help.

Location of Organs

The students are next asked to use a diagram to describe the location of organs of the male urogenital system as they understand it. See Figure SP 5.3.6A. They then read about the urogenital system and correct their original diagram. To ensure understanding of the physical location of organs, they label a side view of an anatomical cross section of a male and compare their drawing with a model torso or Figure SP 5.3.6B. It is important that the student pages be given out ***only as needed.*** See Figures 5.6.1–2.

Human Torso
A human torso with sex organs can usually be borrowed from a high school if one is not available in your school. If a torso is not available, you can substitute anatomical charts.

STUDENT ROLES

Anatomist
Physiologist

MATERIALS

human torso with sex organs (optional)
anatomic charts (optional)
Student Pages 5.3.6A MALE UROGENITAL SYSTEM
5.3.6B BACKGROUND: THE UROGENITAL SYSTEM OF MALES

PRODUCTS

Completed Student Pages

PROCEDURES

1. **Help the students make a concept map of the term urogenital system of a male that includes both the urinary and reproductive systems. Review the animals that they have dealt with, including insects, fish, mice, rabbits, guinea pigs, and so forth.**

   Help them include such things as these:
   - Kidneys.
   - Bladder.
   - Testicles.
   - Penis.
   - Urine.
   - Sperm, sex cells, semen.

2. **Have the students complete Figure SP 5.3.6A to show where they think the urogenital organs are located and how they are connected. See Figure 5.3.6(1).**

   Have the students
   - Draw the organs on the outline. (Location will be determined by the students' experience and logic.)
   - Show how they think that the organs might be connected.
   - Label the organs.

3. **Have the students read the description of the urogenital organs on Student Page 5.3.6B BACKGROUND: THE UROGENITAL SYSTEM OF MALES and have them rework their diagrams as needed.**

4. **Help the students label the side-view diagram of the male urogenital system in Figure SP 5.3.6B.**

5. **Have the students compare their diagrams with a three-dimensional torso model or with anatomic charts.**

   Ask such questions as these:
   - Where are the kidneys located?
   - What is the function of the kidneys?
   - How does the blood get to the kidneys?
   - Where does the urine go from the kidneys?
   - How does the urine get to the bladder from the kidneys?
   - What is the function of the bladder?
   - How is the flow of urine from the bladder controlled?
   - Where does the urine go after leaving the bladder?
   - How does it pass through the penis?
   - What are the functions of the testicles?
   - Where do sperm go after they leave the testicles?
   - How do sperm get to the urethra?
   - How is semen produced?
   - How does semen pass out of the body?

EXTENSION

- Use a videotape to show the workings of the urogenital system.

ILLUSTRATIONS

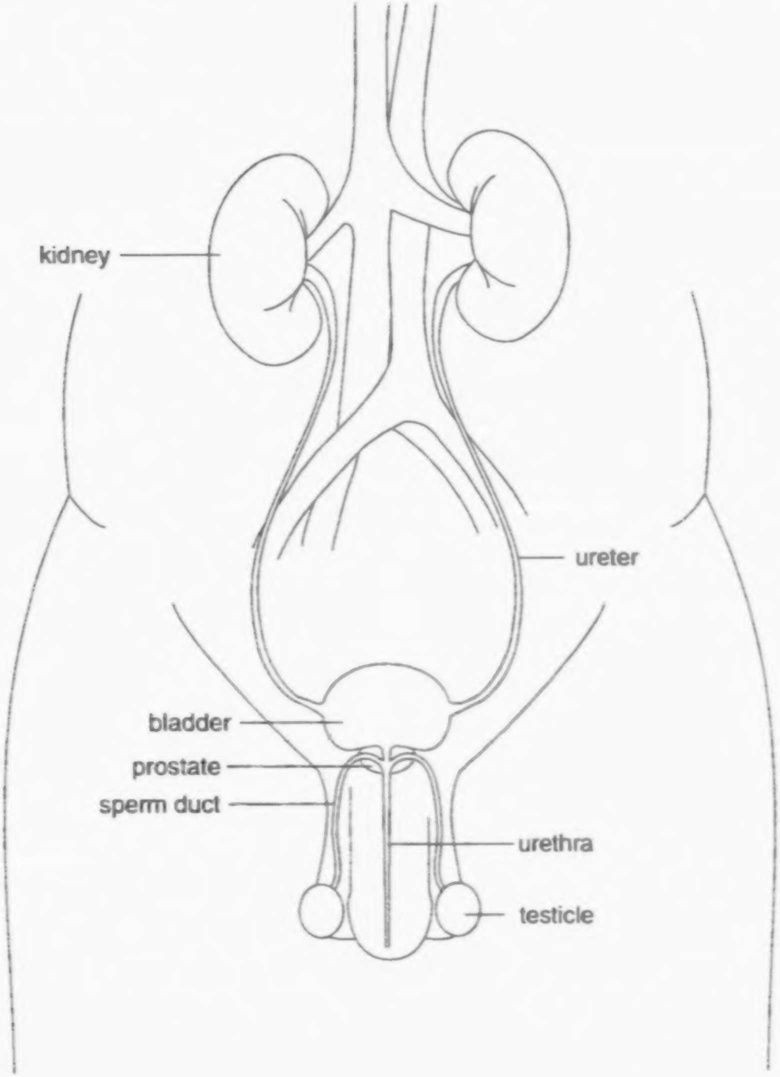

kidney
ureter
bladder
prostate
sperm duct
urethra
testicle

Figure 5.3.6(1) Labeled front view of male urogenital system

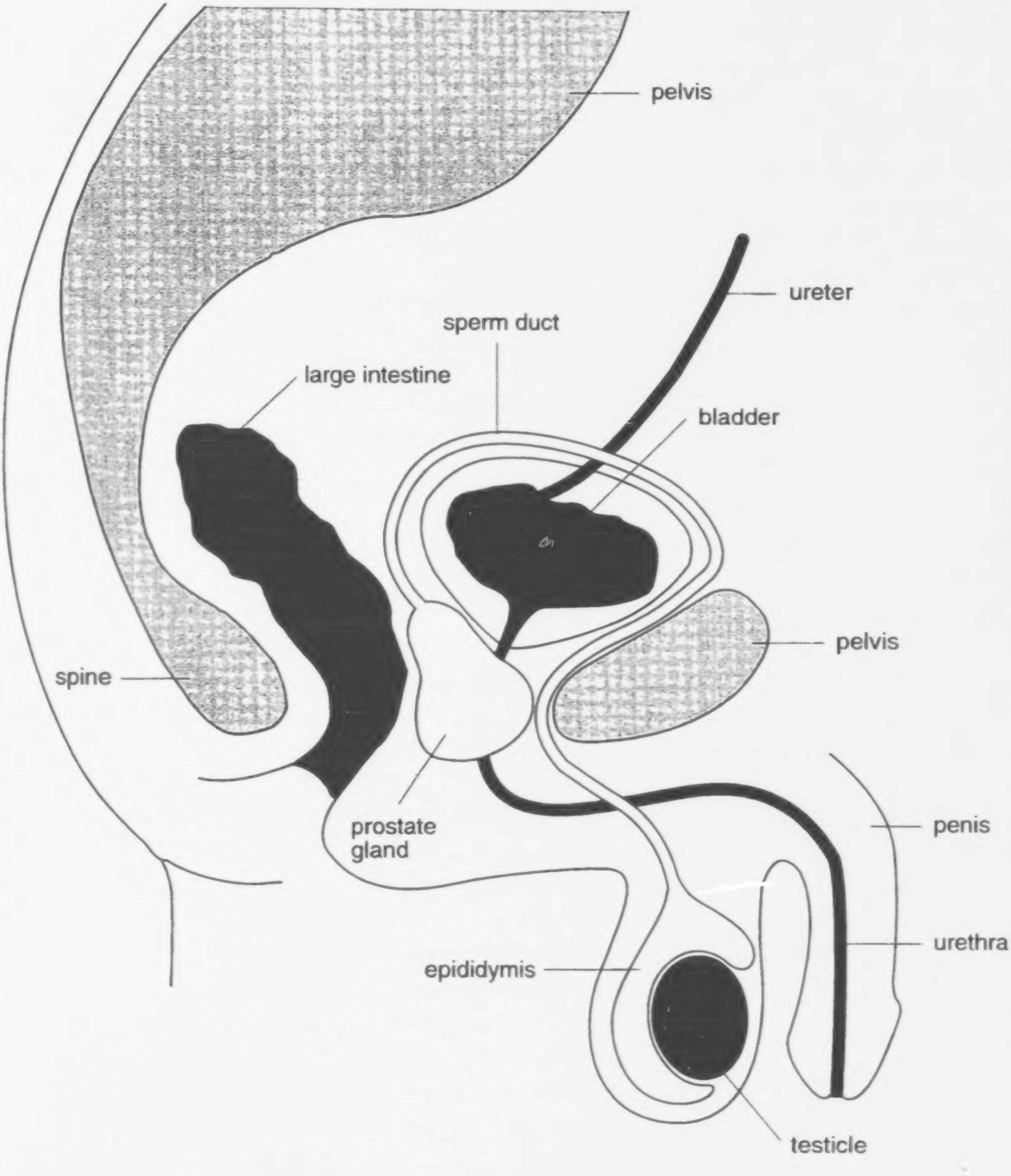

pelvis
ureter
sperm duct
large intestine
bladder
pelvis
spine
penis
prostate gland
urethra
epididymis
testicle

Figure 5.3.6(2) Labeled side view of male urogenital system

DASH

Name__________________________

Date___________________________

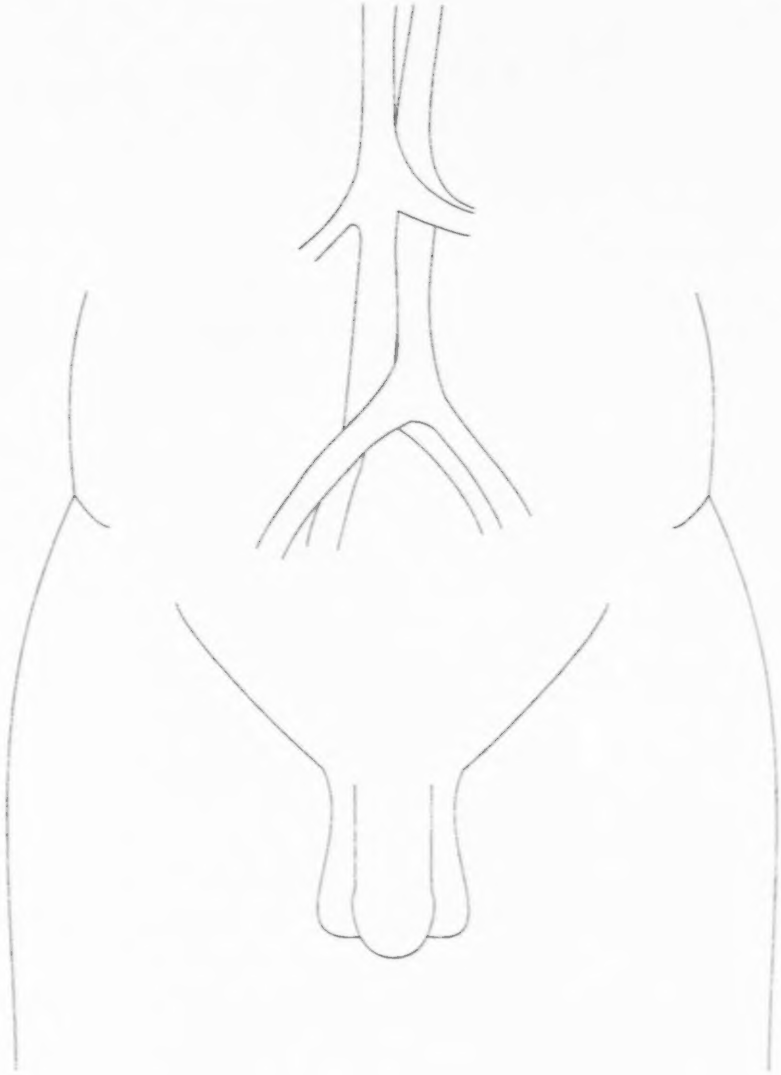
STUDENT PAGE 5.3.6A MALE UROGENITAL SYSTEM

1. **Draw urogenital organs on the outline of the lower body of a male. Show how you think that the organs might be connected. Label the organs. Use Figure SP 5.3.6A.**

2. **Correct your drawing of the urogenital organs and their connections in the light of your reading of Student Page 5.3.6B BACKGROUND: THE UROGENITAL SYSTEM OF MALES.**

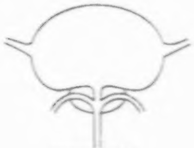
3. **Label the side-view diagram of the male urogenital system shown in Figure SP 5.3.6B.**

Name ____________________



kidneys

bladder



prostate
gland
urethra

testicles

Figure SP 5.3.6A Front view of male urogenital system

DASH

Name________________________

Date________________________

STUDENT PAGE 5.3.6B
BACKGROUND: THE UROGENITAL SYSTEM OF MALES

Mammals are warm-blooded animals that have fur and nurse their young. Cats, dogs, cows, rabbits, guinea pigs, mice, chimpanzees, gorillas, and we humans are all mammals. With little modification, the organ systems of one mammal are very similar to those of another. When we learn about the anatomy of another mammal, we can fairly well apply that information to ourselves.

1. What is the urogenital system?

The urogenital system is really two systems that work together. These are the urinary system and the reproductive system. *Genitals* are the reproductive organs.

2. Why are the two systems considered together?

In males the products from both the reproductive system and the urinary system exit from the body through the same organ, the penis. In other words, both urine and sex cells (sperm) leave the body through the penis.

3. What organs make up the urinary system of males?

The organs of the urinary system are the kidneys, the bladder, and the penis.

4. Where are the kidneys located?

Two kidneys are located close to the spine in the lower half of the torso.

5. What is the function of the kidneys?

The kidneys remove water and waste, particularly urea from the blood. Urea is produced in the liver from the breakdown products of protein. The mixture of waste and water is called *urine*.

Name ____________________

6. What is the path of the blood into and out of the kidneys?

The blood comes to the kidneys directly from the heart through the main body artery called the *aorta.* It leaves the kidneys through the main body vein, the *vena cava,* which takes it directly to the heart. These very large blood vessels lie right against the protective spine.

7. Where does the urine go from the kidneys?

The urine travels to the bladder from each of the kidneys through a tube called the *ureter*.

8. What is the bladder and its function?

The *bladder* is a balloon-like sac that collects and stores urine until it can be gotten rid of. The bladder of an adult human holds about 500 mL of urine. When the bladder is about half full, we can begin to feel the need to urinate. Normally the adult body produces about 1500 mL of urine a day.

9. Where does the urine go after leaving the bladder?

Urine leaves the bladder through a tube called the *urethra*. In the male the urethra passes through a gland called the prostate then through the penis.

10. How do we control the flow of urine from the bladder?

There are a series of muscles that we can voluntarily close and open. Human males usually gain daytime control over these muscles by the age of three years. Night control is often gained at the same time, though some individuals may not gain night control until their teen years.

11. What organs make up the male reproductive system?

Male reproductive organs include the testes, the epididymis, the prostate gland, and the penis.

12. What are the functions of the testicles?

The *testicles* are the organs in which the sperm develop. They are also the organs where chemicals called sex hormones are manufactured. In humans these sex hormones stimulate the growth of a beard and body hair and thicken vocal cords, lowering the pitch of the voice.

Name ______________________

13. Where do sperm go after they leave the testicles?

Once sperm are released, they are moved into a storage tube called the *epididymis.*

14. How do sperm get to the urethra?

Sperm travels in a sperm duct or tube from the epididymis to the point where the prostate gland surrounds the urethra. There the duct empties the sperm into the urethra.

15. What is semen?

Semen is the fluid that carries the sperm out of the penis.

16. How is semen made in the body?

Fluids from the prostate and other glands are added to the fluid bathing the sperm. Together these fluids and the sperm are called *semen.* It is semen that leaves the body carrying the sperm.

17. How long do males produce sperm?

Human males usually start to produce sperm between the ages of 13 and 15 and frequently produce them all their lives.

18. How does the semen leave the body?

Semen leaves the body in a muscular contraction called an *ejaculation.* It is forced out of the penis as a jet of fluid.

Name ______________________

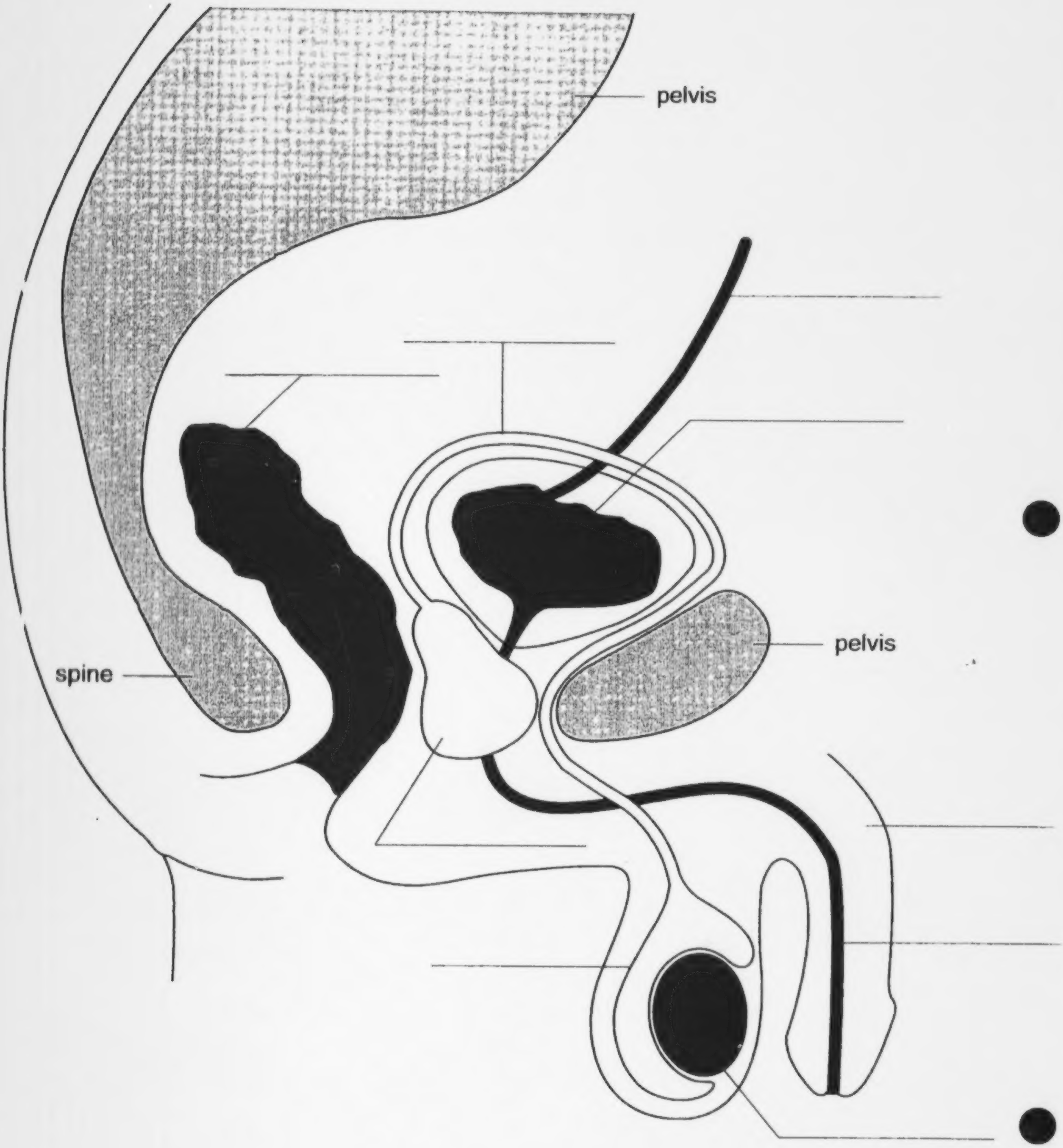

pelvis
pelvis
spine

Figure SP 5.3.6B Side view of male urogenital system

ACTIVITY 5.3.7 FEMALE UROGENITAL SYSTEM

OBJECTIVES

The students

- Make a concept map of the term female urogenital system.
- Use a diagram to show where they believe the female urogenital organs are located.
- Read about the organs.
- Correct their understanding using a human torso or anatomic charts.

BACKGROUND

This activity is one of a series dealing with reproduction. It was designed to follow Activities 5.3.10 EMBRYOLOGY, 5.3.4 CELLS, 5.3.5 CELL QUIZ, and 5.3.6 MALE UROGENITAL SYSTEM, and precede 5.3.8 OVULATION CYCLE and 5.3.9 OVULATION AND PREGNANCY. The students draw upon background information gained in handling pets and studying the organs of fish, mice, and other organisms. Students who have come through the DASH program may remember the scientific names of external genitalia.

Approach

The students begin the activity by making a concept map of the term female urogenital system. They then show their understanding by drawing urogenital organs on the outline of a torso. See Figure SP 5.3.7A. With this inventory of knowledge complete, they then read about the female urogenital system and correct their original diagram. To ensure understanding of the physical location of organs, the students label a side view of an anatomic cross section and compare their drawing with a model torso. See Figure SP 5.3.7B. It is important that student pages be given out ***only as needed.*** See Figures 5.3.7(1–2).

Human Torso

A model human torso with sex organs can usually be obtained from a high school if one is not available in your school. If a torso is not found, anatomic charts can be substituted.

STUDENT ROLES

Anatomist
Physiologist

MATERIALS

human torso with sex organs
anatomic charts
Student Page 5.3.7A FEMALE UROGENITAL SYSTEM
5.3.7B BACKGROUND: THE UROGENITAL SYSTEM OF FEMALES

PRODUCTS

Completed Student Pages

PROCEDURES

1. **Have the students make a concept map of the term female urogenital system.**

   Help them include the following:
   - Kidneys.
   - Bladder.
   - Ovaries.
   - Eggs.
   - Uterus.
   - Vagina.
   - Vulva.
   - Urine.

2. **Have the students use the outline of the body and organs in Figure SP 5.3.7A to show the location of the urogenital organs. See Figure 5.3.7(1).**

   Have them
   - Draw the organs on the outline. (Location will be determined by their experience and logic.)
   - Show how they think that the organs might be connected.
   - Label the organs.

3. **Have the students read the description of female urogenital organs in Student Page 5.3.7B BACKGROUND: THE UROGENITAL SYSTEM OF A FEMALE and have them redraw their diagrams as needed.**

4. **Help the students label the side view of the female urogenital system in Figure SP 5.3.7B. See Figure 5.3.7(2).**

5. **Help the students compare their diagrams with a three-dimensional torso or anatomic chart.**

   Ask such questions as these:
   - Where are the kidneys located?
   - How are male and female urogenital systems different?
   - What is the vulva?
   - What are the female urinary system organs?
   - What is the function of the urinary system in the female?
   - How are the urinary and the reproductive systems associated? (Work to the idea that they are totally separate systems with exit openings in the same general region.)
   - What organs make up the female reproductive system?
   - What are the functions of the ovaries?
   - How many ovaries does the female have?
   - Where do eggs go after they leave the ovaries?
   - Where do the oviducts take the egg?
   - What is the function of the uterus?
   - What is the function of the vagina?

EXTENSION

- Use a videotape to show the workings of the urinary and genital systems.

ILLUSTRATIONS

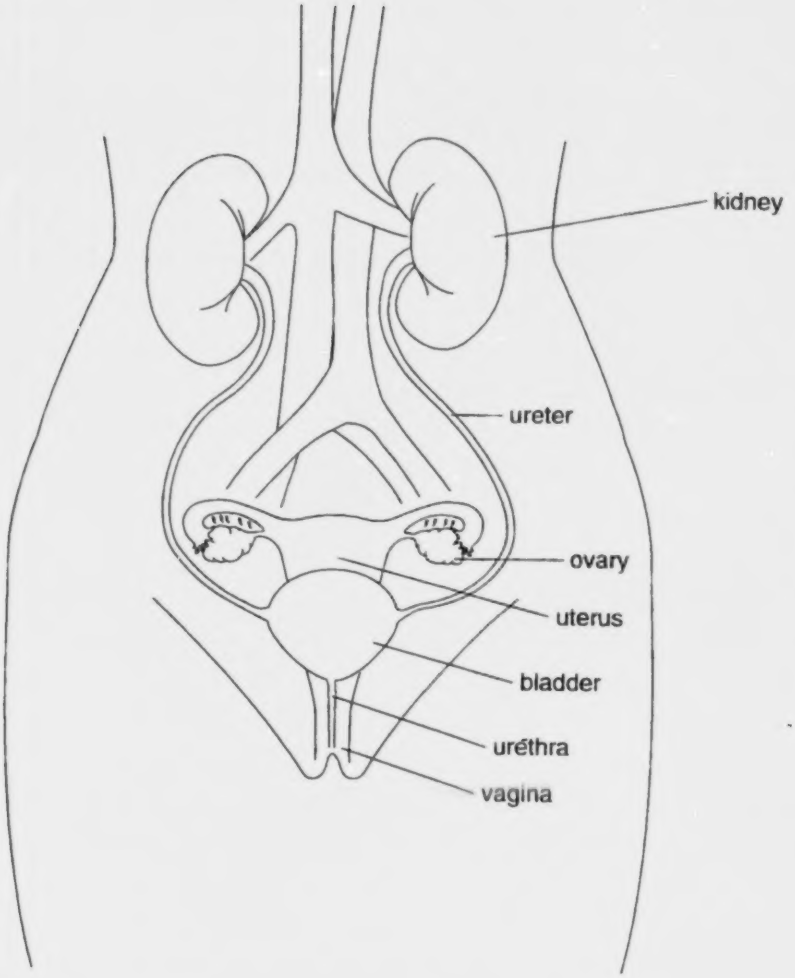

kidney
ureter
ovary
uterus
bladder
urethra
vagina

Figure 5.3.7(1) Labeled front view of female urogenital system

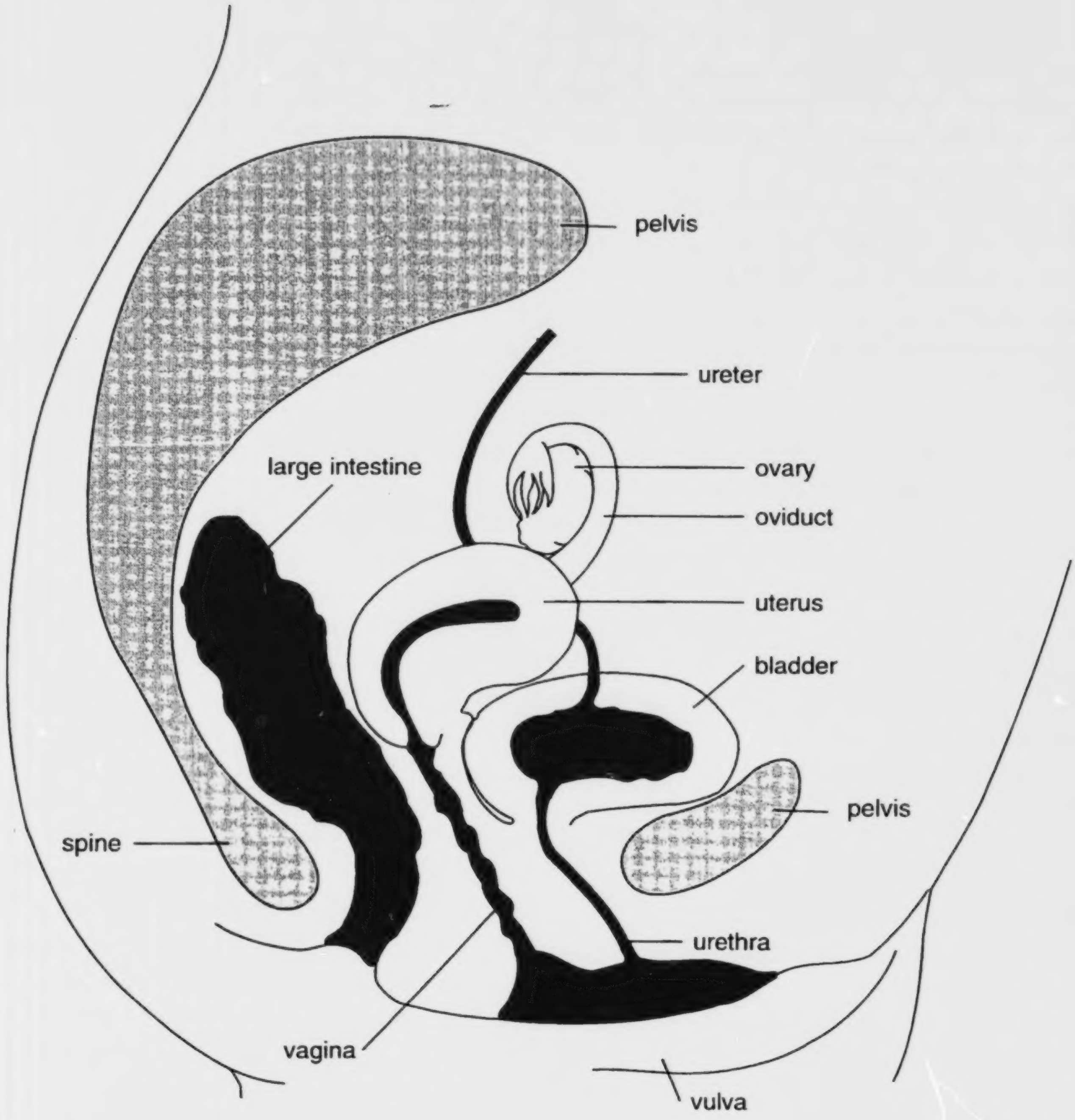

pelvis
ureter
large intestine
ovary
oviduct
uterus
bladder
pelvis
spine
urethra
vagina
vulva

Figure 5.3.7(2) Labeled side view of female urogenital system

DASH

Name__________________________

Date___________________________

STUDENT PAGE 5.3.7A FEMALE UROGENITAL SYSTEM

1. Draw urogenital organs on the outline of the lower body of a female. Show how you think that the organs might be connected. Label the organs. Use Figure SP 5.3.7A.

2. Correct your drawing of the urogenital organs and their connections after reading Student Page 5.3.7B BACKGROUND: THE UROGENITAL SYSTEM OF A FEMALE.

3. Label the side view of the female urogenital system shown in Figure SP 5.3.7B.

Name ______________________________

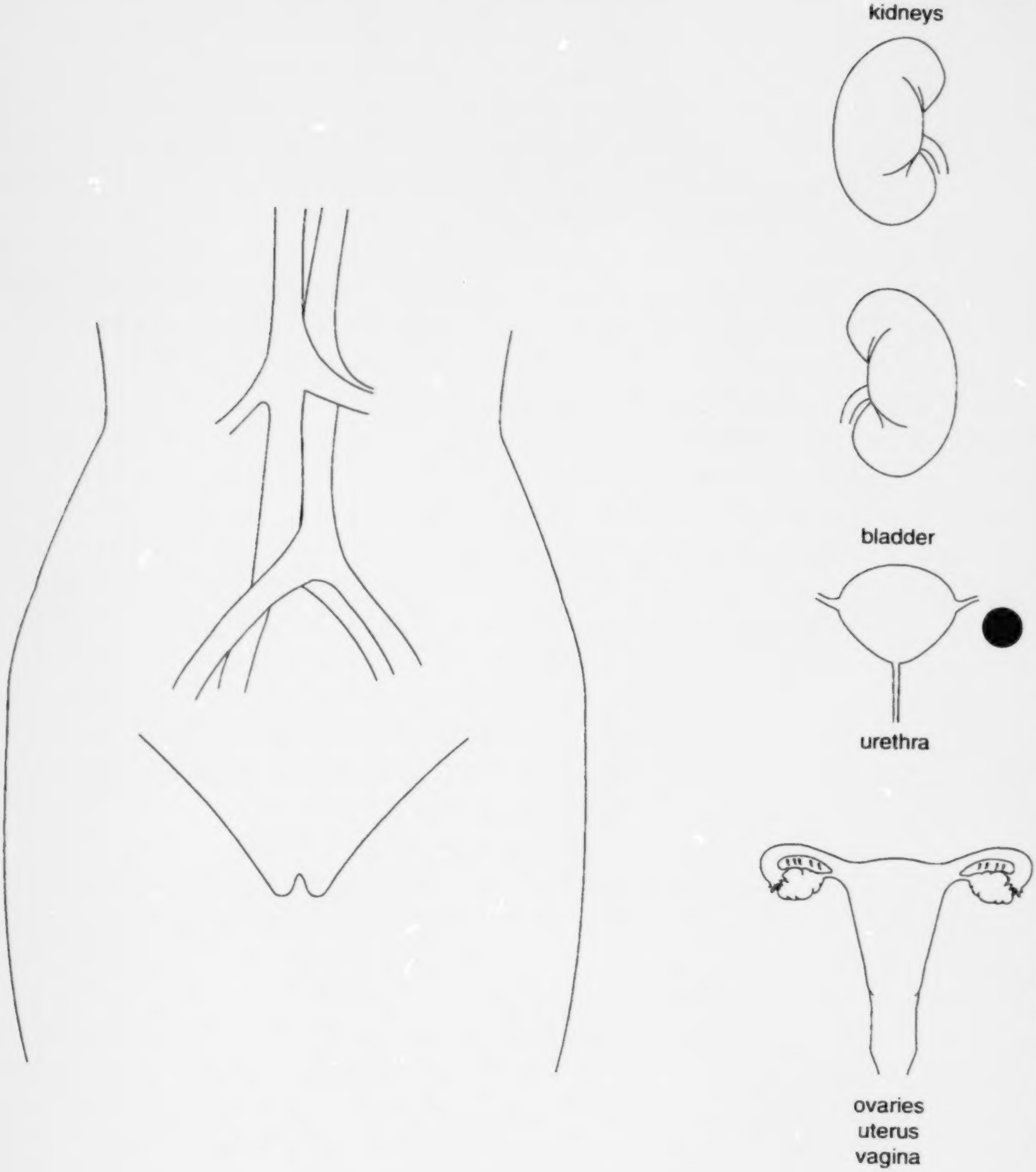

kidneys
bladder
urethra
ovaries
uterus
vagina

Figure SP 5.3.7A Front view of the female urogenital system

DASH

Name____________________________

Date____________________________

STUDENT PAGE 5.3.7B
BACKGROUND: THE UROGENITAL SYSTEM OF FEMALES

Most of the organs in the bodies of human males and females are the same. An exception is found in the reproductive organs, which are different in shape and function.

1. What are the differences in the male and female urogenital systems?

In the human female the urinary system and the reproductive systems are completely separate. Each system has a separate opening. The only thing the two systems share is the vulva. In the male urogenital system the two systems are joined together by the urethra.

2. What is the vulva?

The *vulva* is the visible external fold of tissue covering the openings to both the urinary and reproductive systems of the female.

3. What are the female urinary system organs?

Urinary organs of the female are the kidneys and the bladder. As in the male, the tubes connecting the bladder and kidneys are the *ureters*, and the tube emptying the bladder is the *urethra*.

4. What is the function of the urinary system in the female?

As in the male, the function of the female's urinary system is to remove water and waste from the blood and the product is the liquid called *urine*. Because it carries waste, urine can be used by doctors to tell whether the body is working properly. If the wastes are not normal, it can be assumed that something is wrong in the body.

5. What are the differences in the male and female urinary organs and tubes?

Organs and tubes are the same except for one thing—the urethra of the female empties at the vulva while the urethra of the male empties through the penis.

Name ____________________

6. What organs make up the female reproductive system?

Female reproductive organs include the ovaries, oviducts, the uterus, and the vagina.

7. What are the functions of the ovaries?

The *ovaries* are the organs in which eggs develop. Ovaries are also the place where chemicals called *sex hormones* are manufactured. In human females these sex hormones stimulate the growth of body hair, development of the breasts, and a change in the voice.

8. How many ovaries does the female have?

There are two ovaries, one on the right side of the body and one on the left.

9. How many eggs does the female produce?

At birth the human female baby has 100,000 or more immature eggs in her ovaries. Of all of these eggs, only some 400 will be used in a lifetime. In humans usually one egg is released each month.

10. What is the meant by ovulation?

Ovulation involves the release of an egg by the ovary. In humans this process occurs about once every 28 days.

11. How long does the female produce eggs?

The human female usually produces eggs starting from age 12 to 15 and stops ovulation between 45 and 50.

12. Where does an egg go after it leaves the ovary?

When an egg is mature, it is released and maneuvered into an oviduct.

13. Where does the oviduct take the egg?

The egg travels through an oviduct to the uterus. The oviduct is lined with cells that have tiny hairs called *cilia*. These cilia move in a wave-like motion, pushing the egg down the oviduct.

14. What is the function of the uterus?

The *uterus* is the organ in which a fertilized egg develops into a baby. In humans the uterus is a triangular pouch. The oviducts open into the uterus at the upper corners.

Name ____________________

15. What happens to an egg if it is not fertilized?

If the egg is not fertilized, it disintegrates and passes out of the body during menstruation. If it is fertilized, it can attach itself to the wall of the uterus and develop into a baby.

16. What is the function of the vagina?

The *vagina* is the place where semen is delivered by the male penis.

Name ______________________________

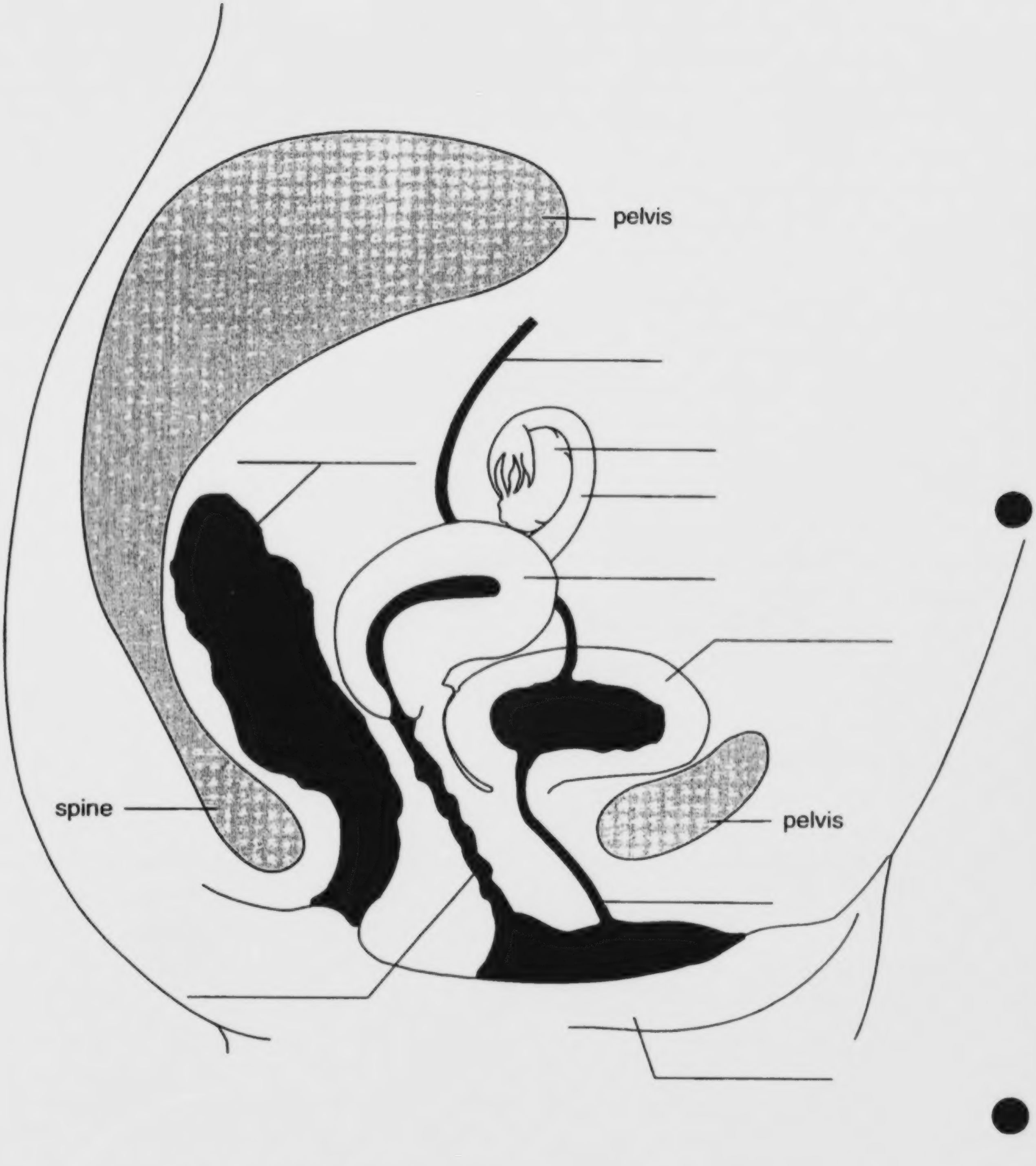

pelvis
spine
pelvis

Figure SP 5.3.7B Side view of the female urogenital system

ACTIVITY 5.3.8 OVULATION CYCLE

The students
- Make a concept map of the term ovulation.
- Read about the ovulation cycle.
- Label a life-sized diagram of the female reproductive system.
- Label a life-sized diagram of a cross section of the ovary.
- Make an average 28-day time line and follow the events of the non-pregnancy ovulation cycle.

BACKGROUND

This activity is one of a series dealing with reproduction. It was designed to follow Activities 5.3.10 EMBRYOLOGY, 5.3.4 CELLS, 5.3.5 CELL QUIZ, 5.3.6 MALE UROGENITAL SYSTEM, and 5.3.7 FEMALE UROGENITAL SYSTEM and precede 5.3.9 OVULATION AND PREGNANCY.

Approach

OVULATION CYCLE begins with the making of a concept map of the term ovulation. The students then read about the ovulation cycle. To reinforce their understanding of the physical location of organs, they label a life-sized view of the female reproductive organs. They then follow a time line of the events of the human ovulation cycle. It is important that student pages be given out ***only as needed.***

Do not succumb to the temptation to make this an exercise in nomenclature. Though the scientific names are used, the important thing is for the students to get a feel for the events in the cycle.

STUDENT ROLES

Anatomist
Physiologist

MATERIALS

human torso model with sex organs
anatomic charts
colored pencils
Student Pages 5.3.8A BACKGROUND: OVULATION CYCLE
5.3.8B OVULATION CYCLE

PRODUCTS

Completed Student Pages

PROCEDURES

1. **Have the students make a concept map of the term ovulation.**

   Help them include such things as these:
   - Female.
   - Eggs.
   - Ovaries.
   - Oviducts.
   - Uterus.
   - Menstruation.
   - Period.
   - Fertilization.
   - 28-day cycle.

2. **Have the students read Student Page 5.3.8A BACKGROUND: OVULATION CYCLE.**

3. **Have the students label the life-sized diagram of the human female reproductive system in Figure SP 5.3.8B(1). See Figure 5.3.8(1) for labeling.**

   Have the students review the functions of the
   - Ovaries.
   - Oviducts.
   - Uterus.
   - Endometrium.
   - Vagina.

4. **Help the students label an enlarged diagram of a cross section of the human ovary in Figure SP 5.3.8B(2). See Figure 5.3.8(2) for labeling.**

Have the students review the functions of the
- Immature follicles.
- Maturing follicles.
- Rupturing follicle.
- Corpus luteum.
- Egg.

5. **Help the students make and color-code an ovulation time line by connecting Figures SP 5.3.8B(3-4).**

Have them
- Use the diagrams of the uterus to follow the travels of the egg by marking an *(x)* in *pencil* so that it can be corrected later if necessary.)
- Use the diagrams of the entire ovary to follow the development and rupture of the follicle. Circle the maturing follicle in *blue*.
- Use the diagrams of the entire ovary and follow the development of the *new* corpus luteum. Circle the new corpus luteum in *yellow*
- Use the diagrams of the entire ovary and follow the degeneration of the *old* corpus luteum. Circle the degenerating corpus luteum in *purple*.
- Use the diagram of the breakdown and buildup of the endometrium to identify the removal of old endometrium. Underline the break-down of the endometrium in *brown* from Day 1 through Day 4.
- Use the diagram of the breakdown and buildup of the endometrium to identify buildup of the endometrium. Underline this in *red* from Day 5 on.

6. **Summarize the activity with the students.**

Ask such questions as these:
- What is the ovulation cycle?
- Where does the ripening of the egg occur?
- What is the ovarian follicle like?
- How large are the follicle and the egg?
- What happens to the follicle once it has broken open?
- How long does the corpus luteum remain on the ovary?
- What is the role of the corpus luteum?
- What is menstrual flow?
- Why do these blood vessels break down?
- How long does the menstruation last?

- What happens to the egg once it is released?
- What happens to the egg once it gets to the uterus?
- Does the ovulation cycle always follow the same timetable?

EXTENSIONS

- Have the students make a list of questions about the ovulation cycle and invite the school nurse or other professional to discuss the ovulation cycle with them.
- Develop a library on the ovulation or menstrual cycle.

ILLUSTRATIONS

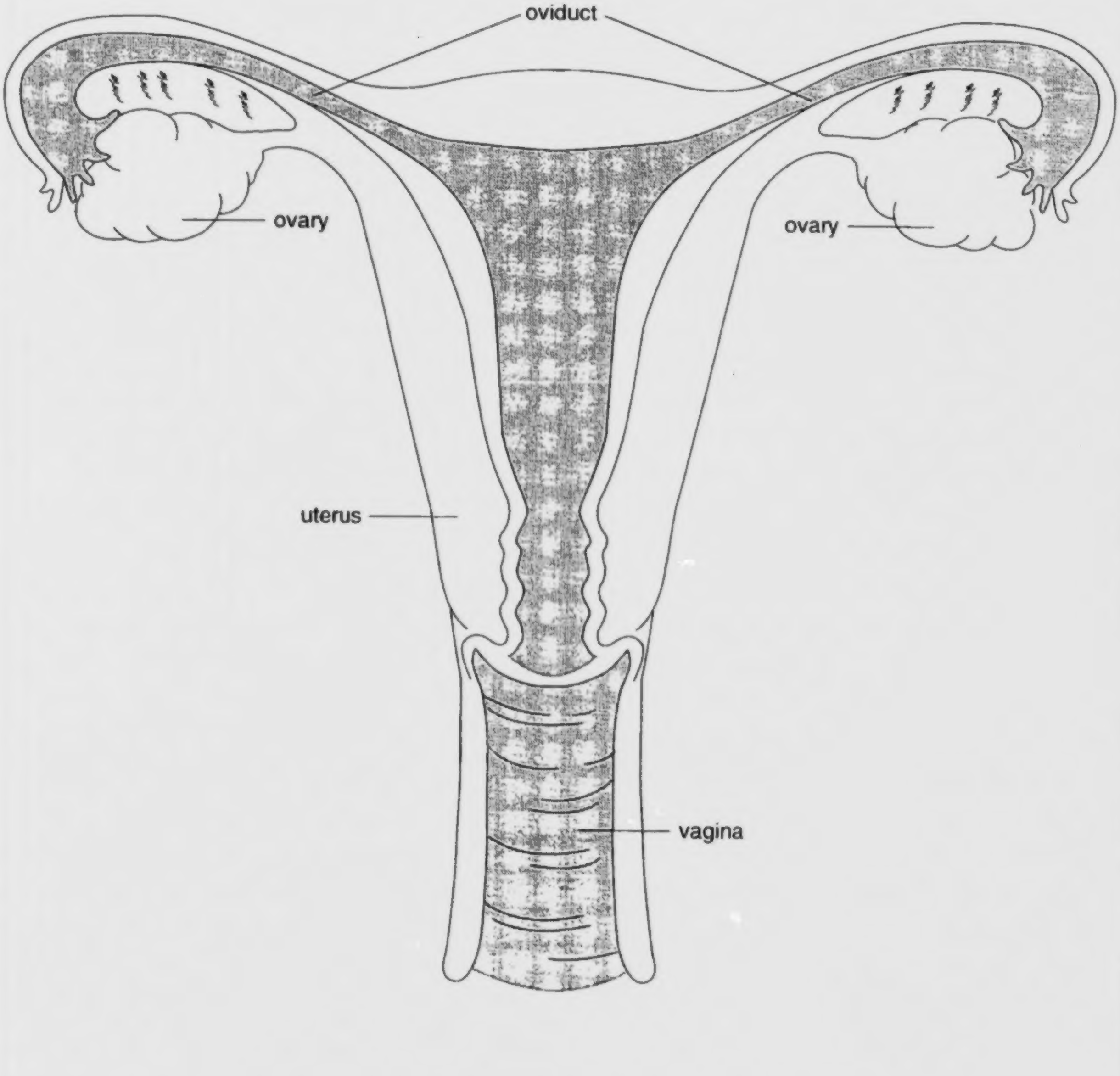

oviduct
ovary
ovary
uterus
vagina

Figure 5.3.8(1) Female reproductive organs

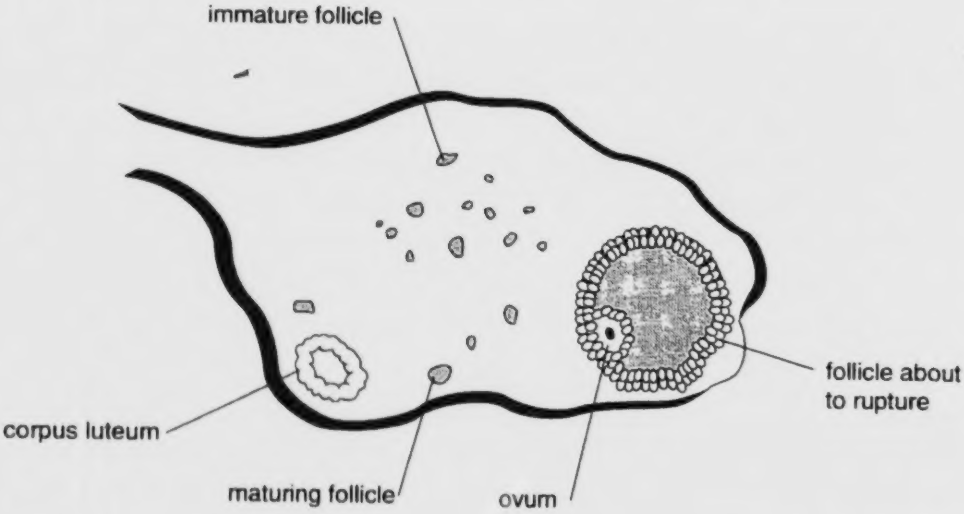
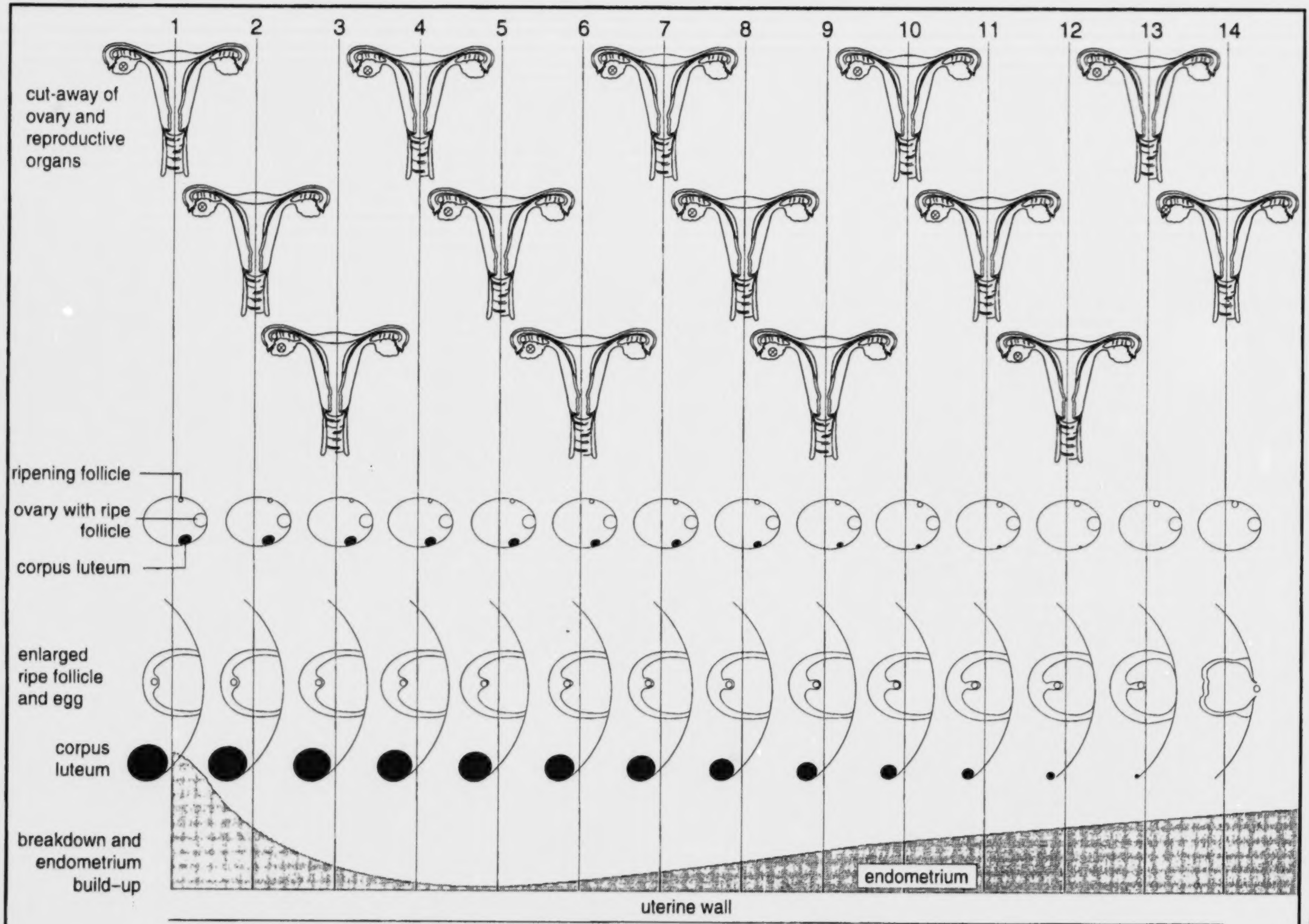

immature follicle
corpus luteum
maturing follicle
ovum
follicle about
to rupture

Figure 5.3.8(2) Enlarged cross section of the ovary twice normal size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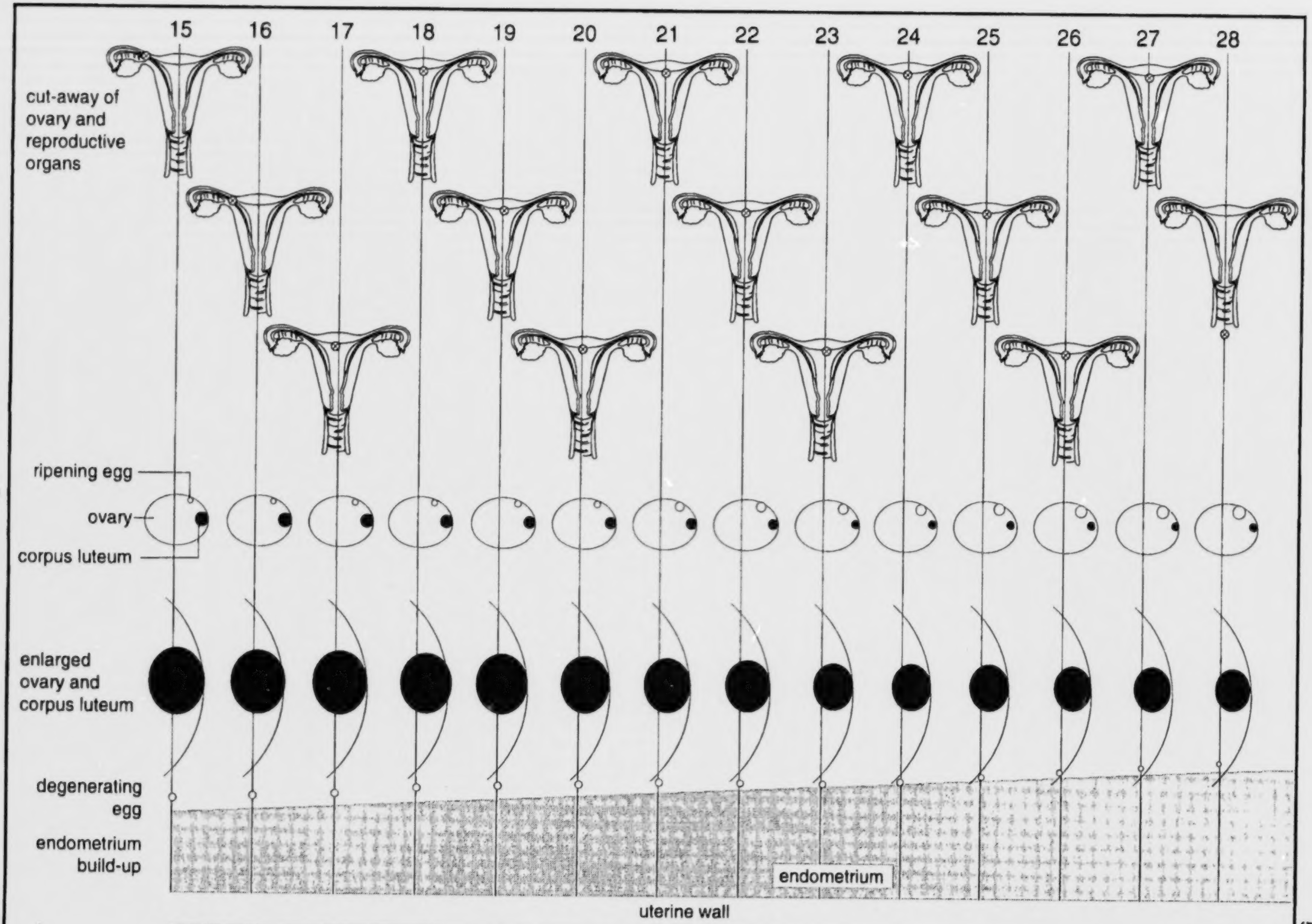
13
14
cut-away of ovary and reproductive organs
ripening follicle
ovary with ripe follicle
corpus luteum
enlarged ripe follicle and egg
corpus luteum
breakdown and endometrium build–up
endometrium
uterine wall

Figure 5.3.8(3) Average ovulation cycle days 1 to 14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26
27
28
cut-away of ovary and reproductive organs
ripening egg
ovary
corpus luteum
enlarged ovary and corpus luteum
degenerating egg
endometrium build-up
endometrium
uterine wall

Figure 5.3.8(4) Average ovulation cycle days 15 to 28

DASH

Name__________________________

Date__________________________

STUDENT PAGE 5.3.8A BACKGROUND: OVULATION CYCLE

Female mammals have only certain times during the year when they can become pregnant. Different mammals have different ovulation cycles

1. What is an ovulation cycle?

In humans an *ovulation cycle* is the series of events that start with the beginning of the ripening of an egg in the ovary. Some 28 to 29 days later it ends with the start of the next ripening of an egg.

2. Where does the ripening of the egg occur?

Ripening occurs in the ovaries that have a huge stock of immature eggs. At any time different eggs will be in different stages of development. Eggs develop in an *ovarian follicle.*

3. What is an ovarian follicle like?

An ovarian follicle looks like a liquid-filled balloon with an egg attached to its wall. Follicles grow very slowly in the ovary. When it is an egg's turn to ripen, its follicle expands very quickly and pushes through the surface of the ovary like a blister. On the 14th day of the cycle the follicle bursts open, releasing the egg.

4. How large are the follicle and the egg?

When ripe and ready to burst the follicle is about 5 mm in diameter, and the egg is about 0.25 mm in diameter. The follicle is about the size of a pencil eraser, and the egg is about the size of the tip of a sharpened pencil.

5. What happens to the follicle once it has broken open?

The follicle heals, forming a scar called the *corpus luteum.* In Latin *corpus luteum* means yellow body.

Name______________________________

6. How long does the corpus luteum remain on the ovary?

The life of the corpus luteum depends on what happens to the egg. If the egg is fertilized and develops into a baby, the corpus luteum lasts till the baby is delivered. If the egg is not fertilized, it disappears at the end of the ovulation cycle.

7. What is the role of the corpus luteum?

It releases *hormones* (chemicals) that help in the development of the egg into a baby.

8. What else occurs as the egg ripens?

In humans ripening of an egg accelerates at the same time as the beginning of menstrual flow. Another name for ovulation cycle is *menstrual cycle.*

9. What is menstrual flow?

Menstrual flow is a passage of blood and tissue out of the body through the vagina. Menstrual flow results from the breakdown of blood vessels in the endometrium.

10. Why do these blood vessels break down?

Every time a new egg gets ready to ripen, the uterus prepares a new bed of spongy tissue that is full of blood vessels to receive it. This bed is called the *endometrium*. It is like the soil of a garden. The fertilized egg will rest on this bed and grow into it. The endometrium will supply the nutrients necessary for the growth of the egg into a baby. If the egg is not fertilized, the old bed is carried away in the menstrual flow.

11. How long does the menstruation last?

The old bed of blood vessels and spongy tissues is usually removed from the system in 1 to 8 days. This time of blood flow is called the *period*. When the flow stops, the building of a new bed or endometrium begins immediately. The average loss of blood is about 60 mL.

Name____

12. What happens to the egg once it is released?

Once released from the follicle, the egg moves into the oviduct. Here it is pushed along toward the uterus by tiny hairs called *cilia*.

13. Where would the egg normally be fertilized?

Normally the egg is fertilized when it is in the upper part of the oviduct.

14. What happens to the egg once it gets to the uterus?

If it is not fertilized, the egg will die within about 24 hours after it is released. If it is fertilized, the developing egg moves into the uterus where it can plant itself in the blood-vessel bed of the uterus. This planting occurs 8–10 days after fertilization.

15. What happens to the blood vessel bed in the uterus once the fertilized egg is planted in it?

The egg develops into an embryo that sends out its own network of blood vessels. These vessels grow so closely to the blood-vessel bed in the uterus that blood fluids can pass between them. In this way the mother nourishes the baby. The blood vessel network of the growing baby and the mother is called a *placenta*.

16. Does the ovulation cycle always follow the same time table?

No. There are many things that can make this ovulation cycle irregular. These include emotional upsets, illness, and even athletic participation.

17. When can fertilization occur?

Fertilization can occur in the 24-hour period following the release of the egg. Sperm remain alive and able to fertilize the egg for 48 hours or 2 days in the fluids of the oviduct and uterus.

18. Why do the sperm and eggs die?

Both the sperm and egg have a limited amount of nutrient material and cannot get full access to the nutrients in the uterus unless they join in fertilization.

Name______________________________

19. What is the sequence of events in the ovulation cycle?

- A follicle on the ovary rapidly enlarges from the beginning of the cycle until it breaks open or ruptures.
- This follicle usually ruptures between Day 12 or 15 of the cycle, releasing an egg. **It is at this time that fertilization normally occurs.**
- After release the egg starts its 8-to-10 day travel down the oviduct to the uterus.
- The egg degenerates if it is not fertilized. **If it is fertilized, the egg starts growing when it is implanted in the endometrium of the uterus.**
- On average, after 28 days the old cycle ends. The length of the cycle is variable, and it is not unusual for it to be as short as 24 days or as long as 35.
- Menstruation begins Day 1 of the new cycle and lasts from 1–8 days, on average 4 days.
- In menstruation the old endometrium is carried away in a flow of blood.
- New endometrium tissue builds from the end of menstruation to the last days of the cycle.
- The corpus luteum starts forming after rupture of the follicle and continues to produce hormones throughout pregnancy. If there is no fertilization, the corpus luteum stops growing in the last days of the cycle. Thereafter it degenerates and is gone by Day 14 of the next cycle.

DASH

Name________________________

Date________________________

STUDENT PAGE 5.3.8B OVULATION CYCLE

1. **Use the terms below to label the life–sized diagram of the female reproductive organs shown in Figure SP 5.3.8B(1). This view is a cross section showing the interior of the organs.**

oviduct
ovary
uterus
vagina

2. **Use the terms below to label the enlarged diagram of the cross section of the ovary shown in Figure SP 5.3.8B(2).**

immature follicle
maturing follicles
rupturing follicles
corpus luteum
ovum or egg

3. **Identify the events on the ovulation cycle shown in Figures SP 5.2.8B(3–4). Connect the figures so that they make a continuous time line for an average 28-day ovulation cycle.**

On the diagrams of the uterus follow the travels of the egg by showing where it is each day during the 28-day cycle. Mark with a small *(x)*.

On the diagrams of the entire ovary follow the
- Development of the ovarian follicle by circling it in *blue*
- Development of the new corpus luteum by circling it in *yellow*
- Breakdown of the old corpus luteum by circling it in *purple*

On the diagram of the breakdown and buildup of the endometrium
- Underline the period of breakdown of the endometrium or menstruation in *brown*
- Underline the interval of buildup of the endometrium in *red*

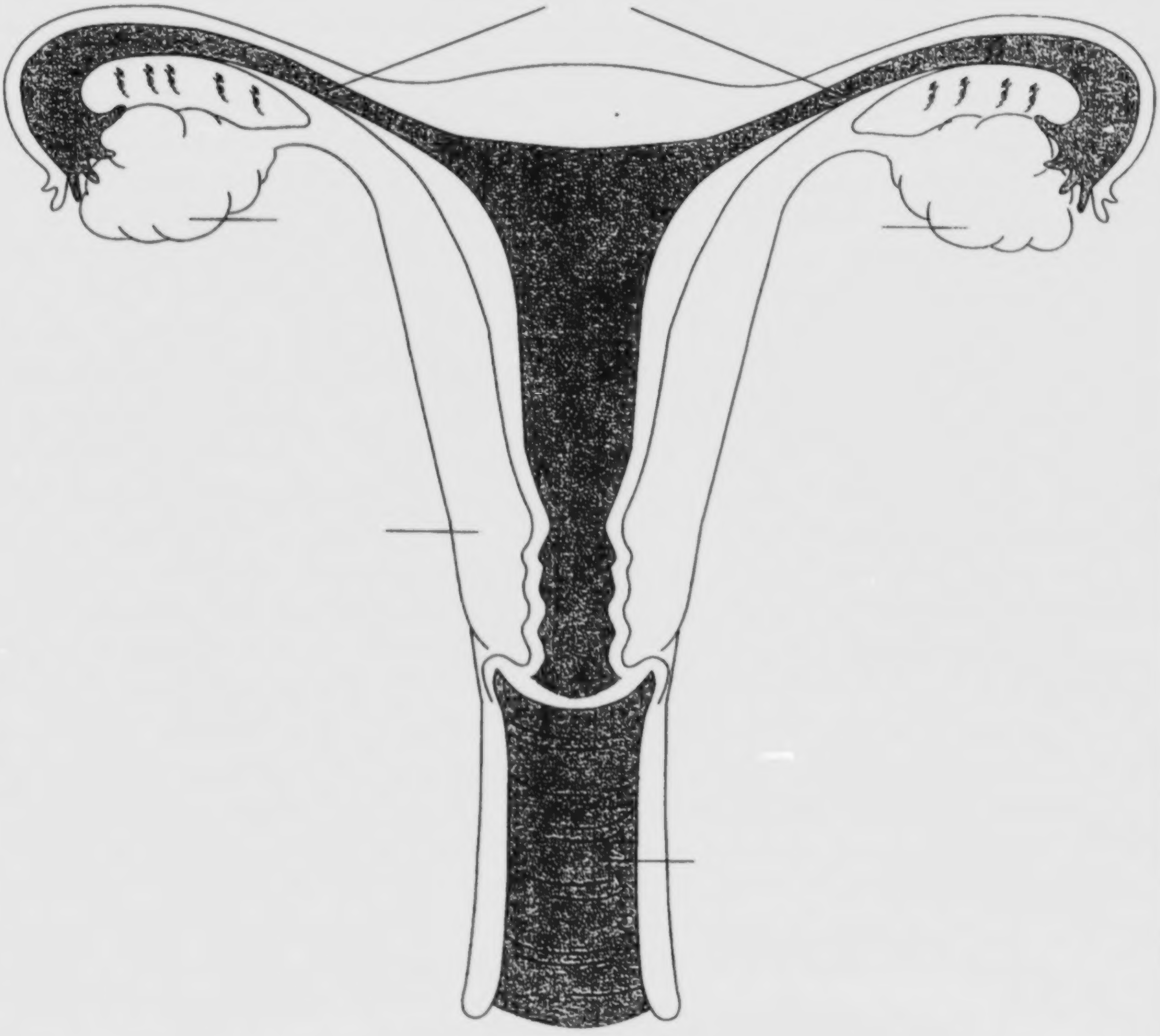


Figure SP 5.3.8B(1) Cross section of female reproductive organs

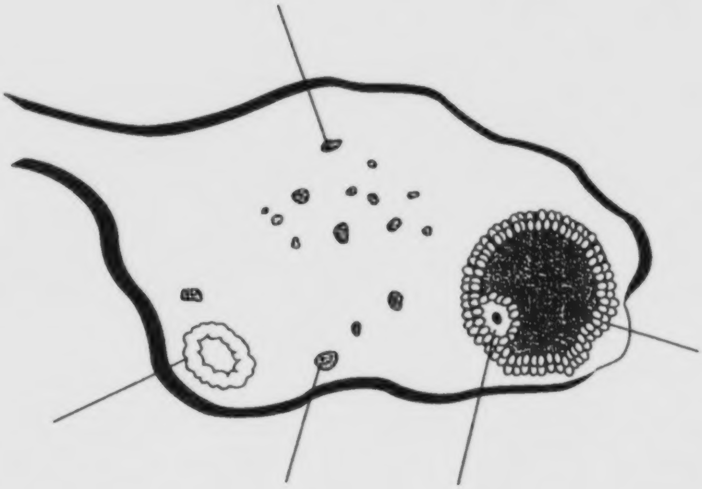
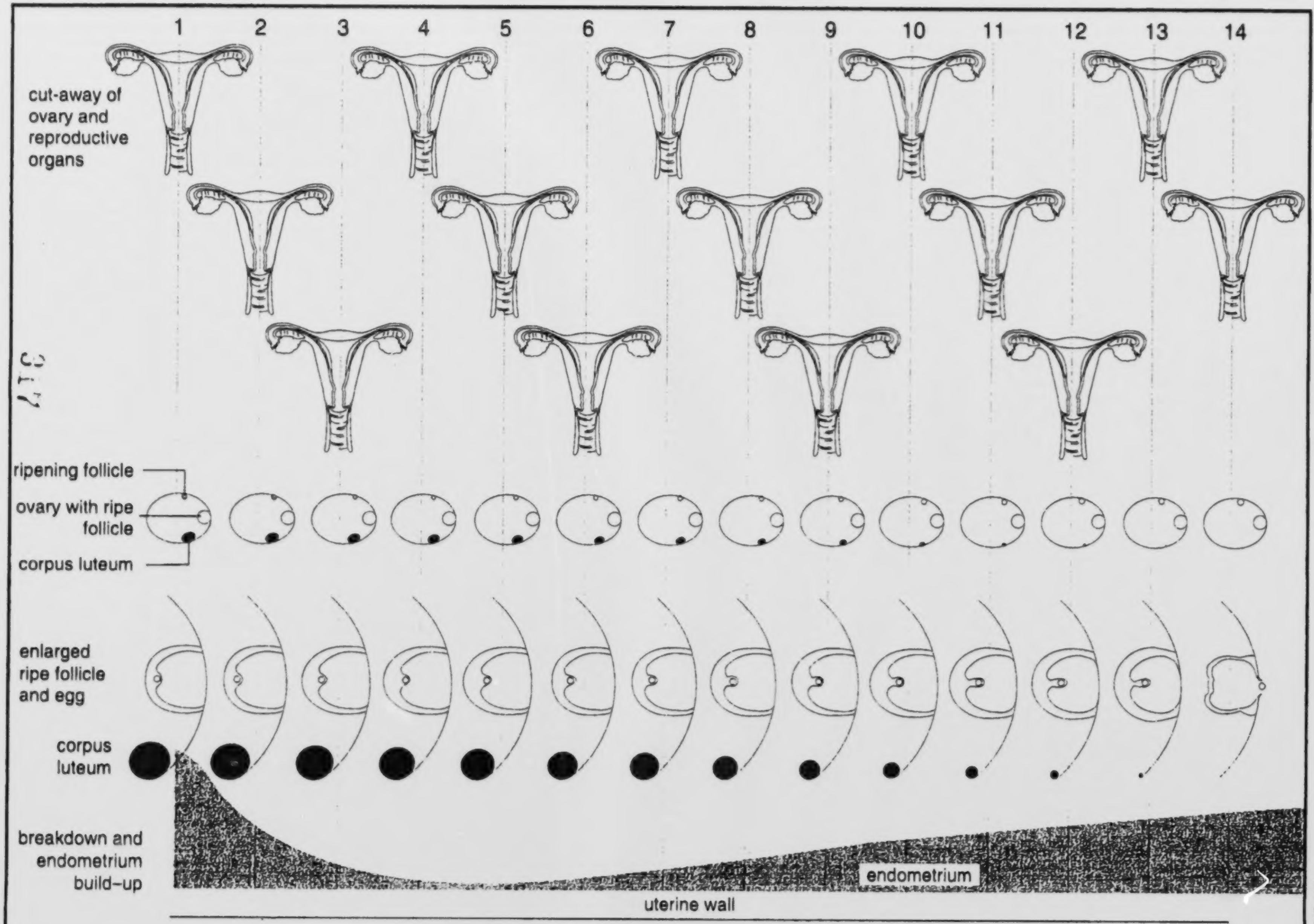


Figure SP 5.3.8B(2) Enlarged cross section of the ovary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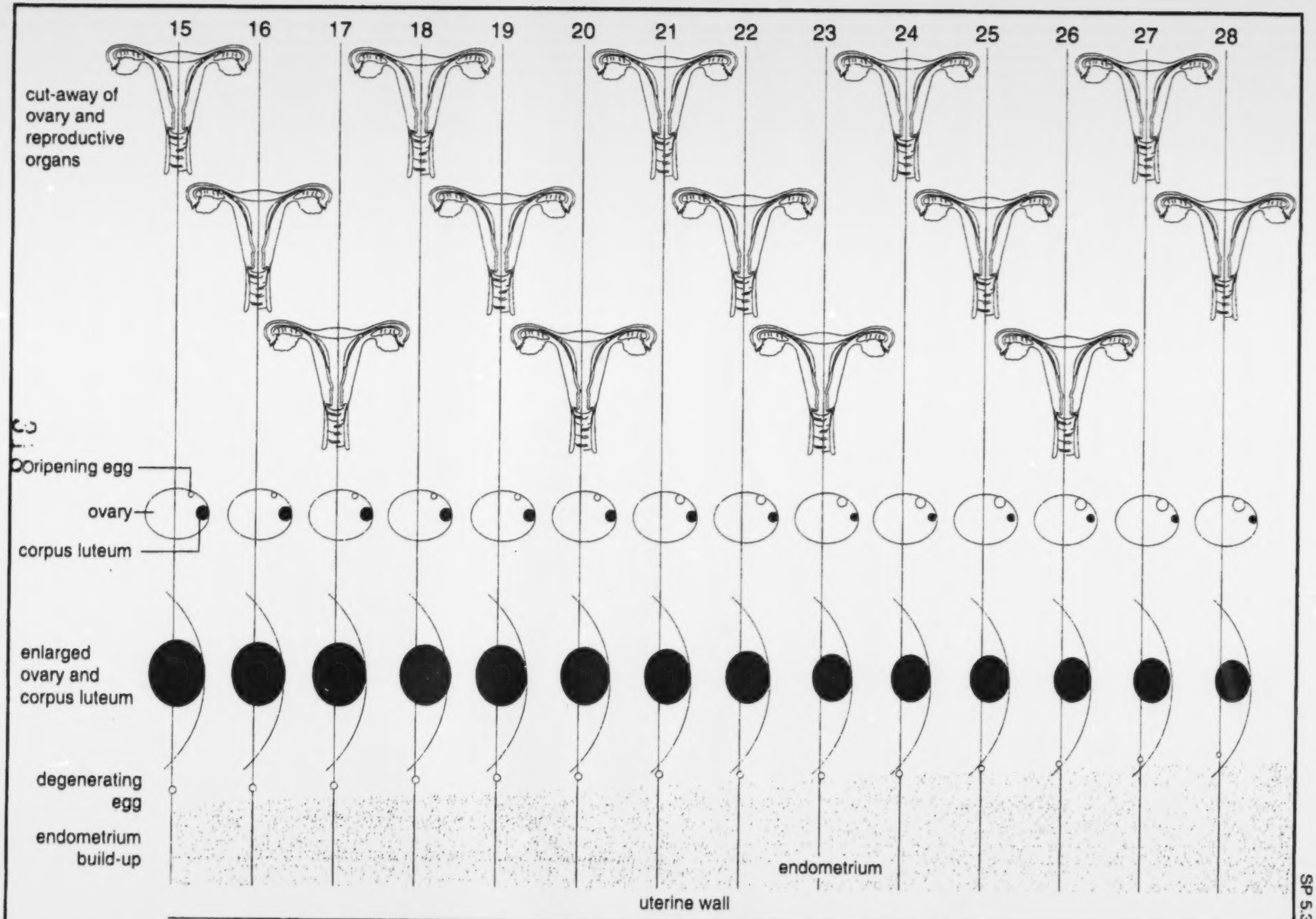
cut-away of ovary and reproductive organs
ripening follicle
ovary with ripe follicle
corpus luteum
enlarged ripe follicle and egg
corpus luteum
breakdown and endometrium build–up
endometrium
uterine wall

Figure SP 5.3.8B(3) Average ovulation cycle days 1 to 14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cut-away of ovary and reproductive organs
ripening egg
ovary
corpus luteum
enlarged ovary and corpus luteum
degenerating egg
endometrium build-up
endometrium
uterine wall

Figure SP 5.3.8B(4) Average ovulation cycle days 15 to 28

ACTIVITY 5.3.9 OVULATION AND PREGNANCY

The students
- Read about ovulation, pregnancy, and delivery.
- Make a time line of ovulation and pregnancy.
- Follow the events in the uterus during the first 14 days of pregnancy .

BACKGROUND

This activity is one of a series dealing with reproduction. It was designed to follow Activities 5.3.10 EMBRYOLOGY, 5.3.4 CELLS, 5.3.5 CELL QUIZ, 5.3.6 MALE UROGENITAL SYSTEM, 5.3.7 FEMALE UROGENITAL SYSTEM, and 5.3.8 OVULATION CYCLE.

Approach

The students make a time line of the events of human ovulation followed by pregnancy. They begin their study with a concept map on pregnancy. As always, this gives the teacher insight into the knowledge and misconceptions of the students. The students then extend their knowledge with a general reading on pregnancy that follows the events of the embedding of the embryo in the endometrium. It is important that student pages be given out ***only as needed.*** Again, do not succumb to the temptation to make this an exercise in nomenclature. Though the scientific names are used, the important thing is for the students to get a feel for the events in pregnancy.

STUDENT ROLES

Anatomist
Physiologist
Pediatrician

MATERIALS

human torso model with sex organs
anatomical charts
colored pencils

Student Pages	5.3.7B	FEMALE UROGENITAL SYSTEM
	5.3.9A	BACKGROUND: OVULATION, PREGNANCY, AND DELIVERY
	5.3.9B	OVULATION AND PREGNANCY

PRODUCTS

Completed Student Pages

PROCEDURES

1. **Have the students make a concept map of the term pregnancy.**

   Help them include such things as these:
   - Fertilization.
   - Fertilized egg.
   - Embryo.
   - Fetus.
   - Placenta.
   - Uterus.
   - Nine months to term.

2. **Have the students read Student Page 5.3.9A BACKGROUND: OVULATION, PREGNANCY, AND DELIVERY.**

3. **Help the students make an ovulation and pregnancy time line using Figures 5.3.9B(1–2) by connecting the figures.**

   Help them do the following:
   - On the diagrams of the uterus use an *(o)* to mark the travels of the egg by showing where it is each day from ovulation on.
   - On the diagrams of the entire ovary follow the development of the ovarian follicle by circling it in *blue*.
   - On the diagrams of the entire ovary follow the development of the new corpus luteum by circling it in *yellow*.
   - On the diagrams of the entire ovary follow the breakdown of the old corpus luteum by circling it in *purple*.
   - On the diagrams of the breakdown and buildup of the endometrium underline the period of breakdown of the endometrium or menstruation in *brown*.
   - On the diagrams of the breakdown and buildup of the endometrium underline the interval of buildup of the endometrium in *red*.
   - On the diagrams of the breakdown and buildup of the endometrium underline the interval of the implanting of the embryo in *orange*.

4. **Summarize the activity with the students.**

Ask such questions as these:

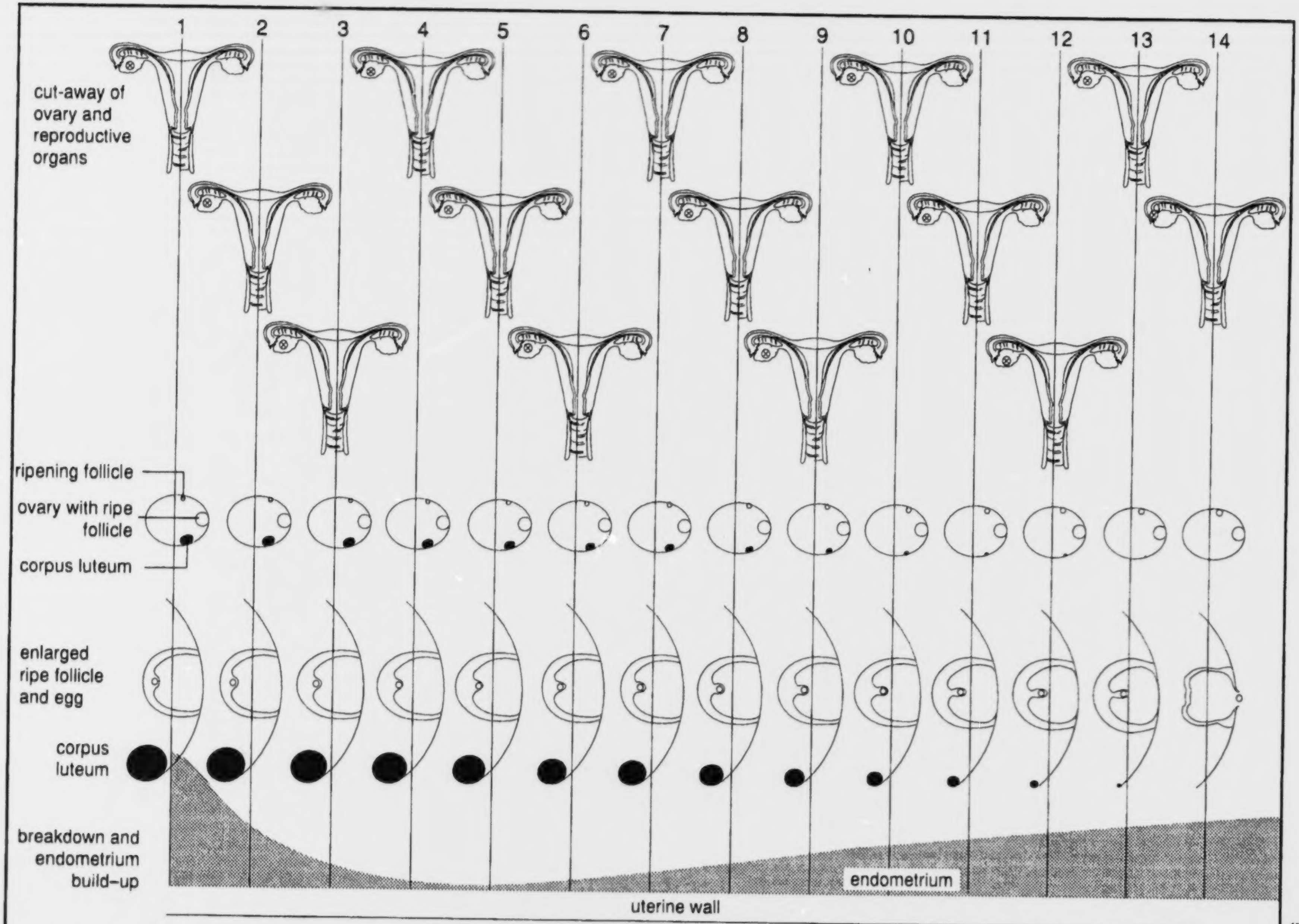
- When can fertilization and pregnancy begin? (Work to agreement that fertilization may occur between the 12th and 15th days.)
- What is the role of the corpus luteum? (Work to agreement that it produces hormones to regulate the development of the baby.)
- What happens to the endometrium? (Work to agreement that it becomes the mother's part of the placenta.)
- How long is the baby normally in the uterus? (Work to agreement that on average it is about 40 weeks or 9 full months.)
- How is the baby protected from some diseases of the mother? (Work to agreement that the blood of the mother and baby don't mix. This helps prevent bacterial cells from infecting the baby, but drugs such as alcohol, cocaine, hallucinogens, and so forth travel to the developing baby in the same way that nutrients do.)

EXTENSIONS

Help the students

- List their questions about pregnancy and have the school nurse or other professional discuss pregnancy with them.
- Develop a library on pregnancy.

ILLUSTRATIONS


1
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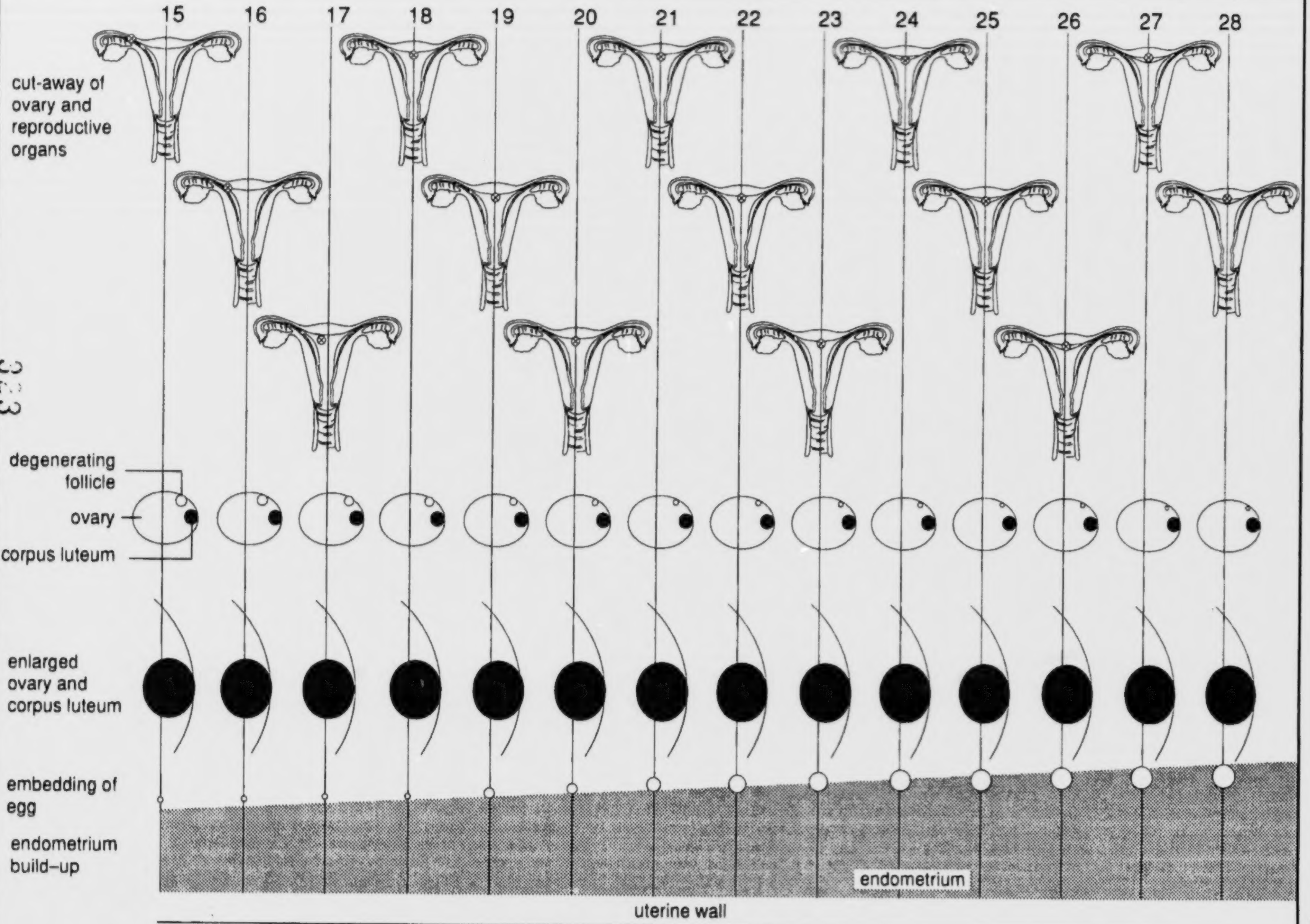
11
12
13
14
cut-away of ovary and reproductive organs
ripening follicle
ovary with ripe follicle
corpus luteum
enlarged ripe follicle and egg
corpus luteum
breakdown and endometrium build–up
endometrium
uterine wall

Figure 5.3.9(1) Average ovulation cycle days 1 to 14


15
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27
28
cut-away of ovary and reproductive organs
degenerating follicle
ovary
corpus luteum
enlarged ovary and corpus luteum
embedding of egg
endometrium build–up
endometrium
uterine wall

Figure 5.3.9(2) Pregnancy days 15 on

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DASH

Name________________________

Date________________________

STUDENT PAGE 5.3.9A
BACKGROUND: OVULATION, PREGNANCY, AND DELIVERY

1. What is pregnancy?

Pregnancy is the condition that exists when a mother is carrying a fertilized egg, an embryo, or a fetus in her body.

2. When does pregnancy start?

Pregnancy starts at the point when an egg is fertilized by a sperm. In humans this usually occurs 12 to 15 days after the start of the menstruation.

3. Where does fertilization occur in the body?

Fertilization of the egg usually occurs in the upper end of the oviduct just after the egg is released by the ovary, the organ where eggs develop. The oviducts are also called the *fallopian tubes*.

4. What happens after fertilization?

The egg immediately starts to divide into 2 cells, then into 4, then 8, 16, 32, and so forth. At this point an *embryo* has started to form.

5. Where does the developing embryo go next?

For 8 to 10 day it travels down the oviduct toward the uterus. It is constantly pushed along by tiny moving *cilia*, or hairs.

6. Once the embryo reaches the uterus what does it do?

It plants itself in the rich blood-vessel bed of the endometrium and begins to grow its own blood-vessel system among the vessels of the endometrium. Together, the baby's and mother's systems of blood vessels become the placenta.

Name________________________

7. What are the results of the embryo's developing its own blood-vessel system?

Neither the embryo nor the fetus ever becomes a part of the mother's body. They are like a ship tied to a dock, getting all its supplies from the "motherland." The mother supplies the developing baby nutrients through fluids that pass out of her blood vessels and enter the vessels of the developing baby. This protects the baby from the passage of infectious bacteria and some chemicals in the mother's blood that might harm the baby.

8. How long does the developing baby stay in the uterus?

This a variable period. A normal birth takes place some time near the end of the ninth month after pregnancy begins. A premature child may be born and saved after about the 28th week of pregnancy. Often a baby may arrive several weeks after the ninth month.

9. What happens in the ovaries during the period of the pregnancy?

The ovaries stop producing eggs and the corpus luteum grows into a gland that helps regulate the pregnancy.

10. How does the developing baby get its nutrients from the placenta?

In the embryo stage an umbilical cord is formed. This cord has both venous and arterial vessels carrying blood to the placenta and back into the body.

11. What happens to the umbilical cord at birth?

The umbilical cord is cut and tied off so that the newborn becomes completely independent of the mother.

12. How does the baby leave the mother?

Normally when the fetus is fully developed, the mother will go into a condition called *labor* and will push the baby out of the uterus through the vagina into the outside world. The muscles used are those of the abdomen, the diaphragm, and the uterus itself. This is called *natural delivery*.

13. What happens to the placenta?

It is expelled from the uterus right after the baby is born.

Name______________________________

14. What is a cesarean section?

A *cesarean section* is a surgical delivery of a baby. The lower part of the abdomen is cut open and the baby is removed through a second cut in the wall of the uterus. Cesarean delivery is done when the opening in the pelvis is too small for the baby to pass, when there are complications in the growth of the placenta, or when problems are anticipated in natural delivery.

15. What happens to the uterus after delivery of the baby?

Usually the uterus has completely healed within a month of delivery.

Name__________________

Date____________________

DASH

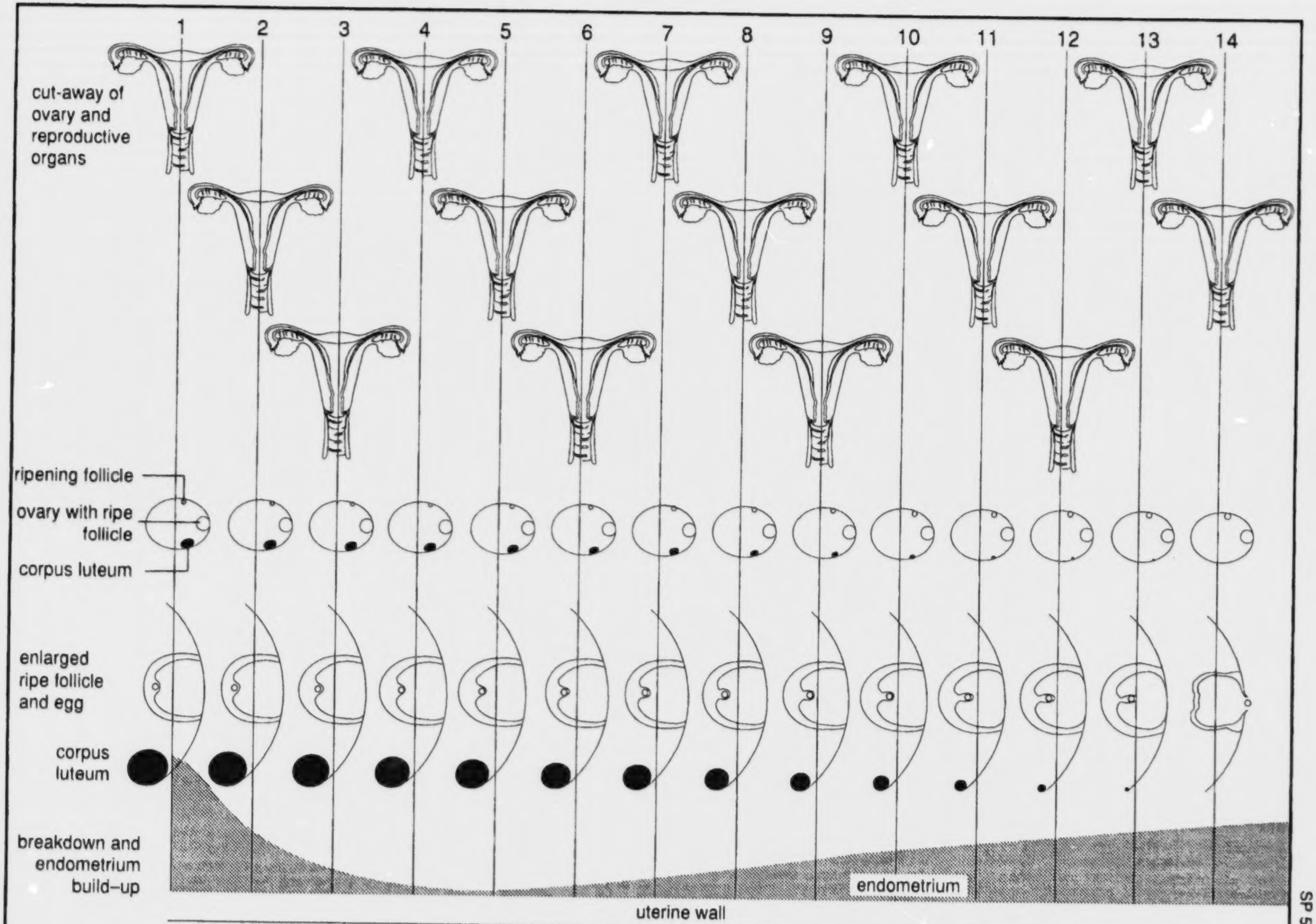
STUDENT PAGE 5.3.9B OVULATION AND PREGNANCY

Identify the events of ovulation, fertilization, and the first 14 days of pregnancy shown in Figures SP 5.3.9B(1–2). Connect the figures so that they make a continuous time line.

1. On the diagrams of the uterus follow the travels of the fertilized egg and embryo by showing where they are each day after ovulation. Mark the progress with an *(o).*

2. On the diagrams of the entire ovary follow the
   - Development of the ovarian follicle by circling it in *blue*
   - Development of the new corpus luteum by circling it in *yellow*
   - Break down of the old corpus luteum by circling it in *purple*

3. On the diagram of the breakdown and buildup of the endometrium
   - Underline the period of breakdown of the endometrium or menstruation in *brown*
   - Underline the buildup of the endometrium in *red*
   - Underline the time of growth of the embryo in the wall of the uterus in *orange*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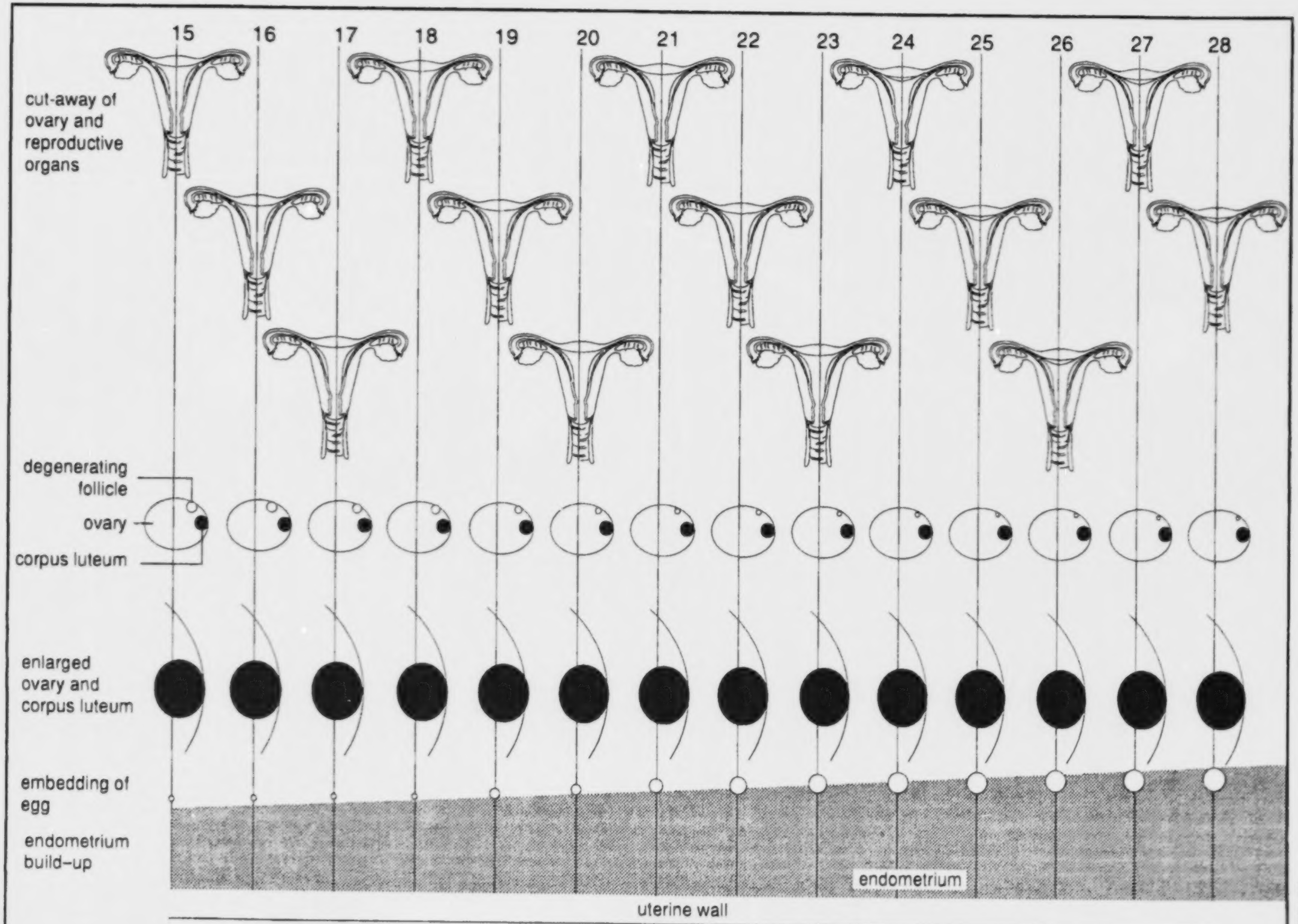
cut-away of ovary and reproductive organs
ripening follicle
ovary with ripe follicle
corpus luteum
enlarged ripe follicle and egg
corpus luteum
breakdown and endometrium build–up
endometrium
uterine wall

Figure SP 5.3.9B(1) Average ovulation cycle days 1 to 14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cut-away of ovary and reproductive organs
degenerating follicle
ovary
corpus luteum
enlarged ovary and corpus luteum
embedding of egg
endometrium build–up
endometrium
uterine wall

Figure SP 5.3.9B(2) Pregnancy days 15 on

ACTIVITY 5.3.10 EMBRYOLOGY

The students
- Make a concept map of the term embryology.
- Follow the development of the human embryo and fetus by looking at drawings of their changes at regular intervals.
- Graph the development of the embryo and fetus.
- Make a model showing the volume changes of the embryo and fetus.

BACKGROUND

This activity is usually the first of a series dealing with reproduction. Companion activities are 5.3.4 CELLS, 5.3.5 CELL QUIZ, 5.3.6 MALE UROGENITAL SYSTEM, 5.3.7 FEMALE UROGENITAL SYSTEM, 5.3.8 OVULATION CYCLE, 5.3.9 OVULATION AND PREGNANCY, and 5.3.11 BODY CHANGES.

Community Sensitivity

If your community is sensitive about study of human reproduction, you will need to discuss the use of this material with your administrator.

Time Line

Ideally, the first drawing of the fertilized egg will be posted early in the fall of the year. Successive drawings should be posted daily for two weeks and then weekly to make a pictorial time line of a pregnancy. If there is not enough time to complete the series, a premature birth can be simulated or the last stages of development can be accelerated. See embryo-fetus drawings.

The activity begins with the making of a concept map of the term embryology. This will give a review of previous DASH work with frogs, chicks, and fish. If the students have their drawings of the developing frog, chick, and fish embryos, they can make a bulletin board display.

Graphs of Data

As the life-sized diagrams of the developing embryo and fetus are posted, the students graph changing length, mass, and volume. Near the termination of the pregnancy they make a volumetric display of the growing fetus using plastic bags or balloons filled with water.

Specific Gravity

Help the students recall that the *specific gravity* of flesh is just about 1, meaning that the human body on average has a mass that is the same as an equal volume of water. Thus 1 mL of water has a mass of 1 g and 1 mL of flesh has a mass of 1 g. This can be retested by determining the mass of 10 mL of ground beef, which will have a mass of very close to 10 g.

Mass

The masses of human eggs are very small, about 0.000005 g. After fertilization the egg becomes an embryo. During the first 13 days of growth the mass of the embryo can be measured only on sophisticated balances. After about the 14th day or second week the mass of the embryo is sufficiently great to allow measurement on balances that students might operate. After the 8th week the embryo becomes a fetus with a mass of about 2.00 g.

The data in the diagrams are average data for a baby that has a birth mass of 3,400 g (3.4 kg) or a birth weight of 7-1/2 lb. At any date a particular baby will have a mass and length that will probably differ slightly from the average.

Increase in Body Mass

As the students are modeling the increase in volume and mass of the baby, point out that the mother is also undergoing an additional increase in body mass. At the end of a 40-week pregnancy the body mass of the mother will have increased about 9–14 kg—an increase in body weight of about 20–30 lb. The average increase will be about 11 kg in body mass and about 24 lb in body weight. Table 5.3.10 shows how mass and weight gains are distributed in an average pregnancy.

Amniotic fluid is the fluid in the uterus surrounding the baby. It provides a protective cushion and temperature regulation and allows the fetus to move. Note in the table below that only a third of the increase in body weight or mass is produced by the baby.

Table 5.3.10 Distribution of mass and weight gains in pregnancy

	Gain in mass	Gain in weight
Baby	3.4 kg	7.5 lb
Placenta	1.1	2.4
Amniotic fluid	1.2	2.6
Mother's body	2.3	5.0
Blood	2.7	6.0
Total gain	10.7 kg	23.5 lb

Language Distinction

In the first days of development we speak of an "embryo." When human-like characteristics emerge, we speak of a "fetus."

Reflections on Pregnancy

After completion of the growth and development sequence or during its last several weeks, it is important to look at the wider implications of pregnancy. Pregnancy can be connected with other studies during the course of the year, including growth and development, nutrition, tobacco, alcohol, drugs, and sexually transmitted diseases. Other studies such as the economics of raising a child are equally important.

This is an opportune time for study of such questions as these:
- What are the optimum years for reproduction and what is the prognosis for the health of a baby born to a mother who has not yet reached full maturity?
- What are the special nutritional needs of a mother during pregnancy and after?
- What effects do tobacco, alcohol, and drugs have on a developing baby?
- What effects do different sexually transmitted diseases have on a developing baby?
- What does it take to raise a baby in terms of money and other resources?

These questions can be the topics of group or individual research, topics discussed with guest speakers, or topics brought up in a guided field trip to a maternity ward. The students can usually get information from public health agencies such as the office of Food and Nutrition Services of the U.S. Department of Agriculture.

STUDENT ROLE

Anatomist
Obstetrician

MATERIALS

balance
graduated container for determining volume
plastic bags or balloons
string
life-sized embryo-fetus drawings for posting (optional)
Student Page 5.3.10 EMBRYOLOGY

PRODUCTS

Completed Student Pages

PROCEDURES

1. **Help the students make a concept map of the term embryology.**

   Help them include such things as these:
   - Science.
   - Growth.
   - Development.
   - Egg.
   - Fertilization.
   - Embryo.
   - Fetus.
   - Stages.

2. **Post the life-sized embryo-fetus drawings. Help the students make a nine-month pictorial time line of the development of the human embryo and fetus from conception through birth. Have them make their own data collection table and use Student Page 5.3.10 EMBRYOLOGY for graphing their data.**

   Help the students
   - Review the development of the embryo daily for the first week.

- Review the development of the embryo weekly for the remainder of the month.
- Review the development twice monthly thereafter until birth.
- Label the structures undergoing change.
- Recall that the specific gravity of a human is 1 and that 1 mL of our body has an average mass of 1 g. (This is the same average specific gravity of the embryo or fetus.)
- Keep an ongoing graph of the relationship between length and age, between mass and age, and between volume and age.
- At the end of the pregnancy summarize and graph the data collected.

3. **At the end of the pregnancy have the students make volumetric models of the developing fetus using plastic bags or balloons and water. Add these to the pictorial time line to get a visual sense of volume.**

Have the students

- Fill a pouch made from a plastic bag or balloon with water equal in mass to the mass of the fetus.
- Tie the mouth of the pouch, allowing any extra plastic to represent the placenta.
- Cut out and attach copies of the appropriate drawing of the fetus to the pouch.

4. **Help the students interpret the graphs.**

Ask such questions as these:

- What happens to the length of the embryo and fetus over time? (Get at the idea that the embryo and fetus constantly grow in length and that the growth is faster in the beginning then seems to slow.)
- What happens to the volume and mass of the embryo and fetus over time? (Work to the observation that they increase in very much the same way as the length of the fetus.)
- What is the relationship between the mass and the volume? (They increase in a constant relationship of 1 g for each cubic centimeter or milliliter of volume change. This is because the specific gravity of the human body is 1, the same as that of water. One gram of water occupies 1 cubic centimeter or 1 mL.)
- What is the relationship between changes in the length and the volume and the length and the mass? (They all increase, but the mass and volume increase faster than the length. Some students

may want to speculate on what causes this. The explanation is complicated, but if there is speculation, help them see that volume is a cubic dimension and length is only one dimension. The relationship, however, will not be one of a pure cube to a linear dimension because we humans are not cubes.)

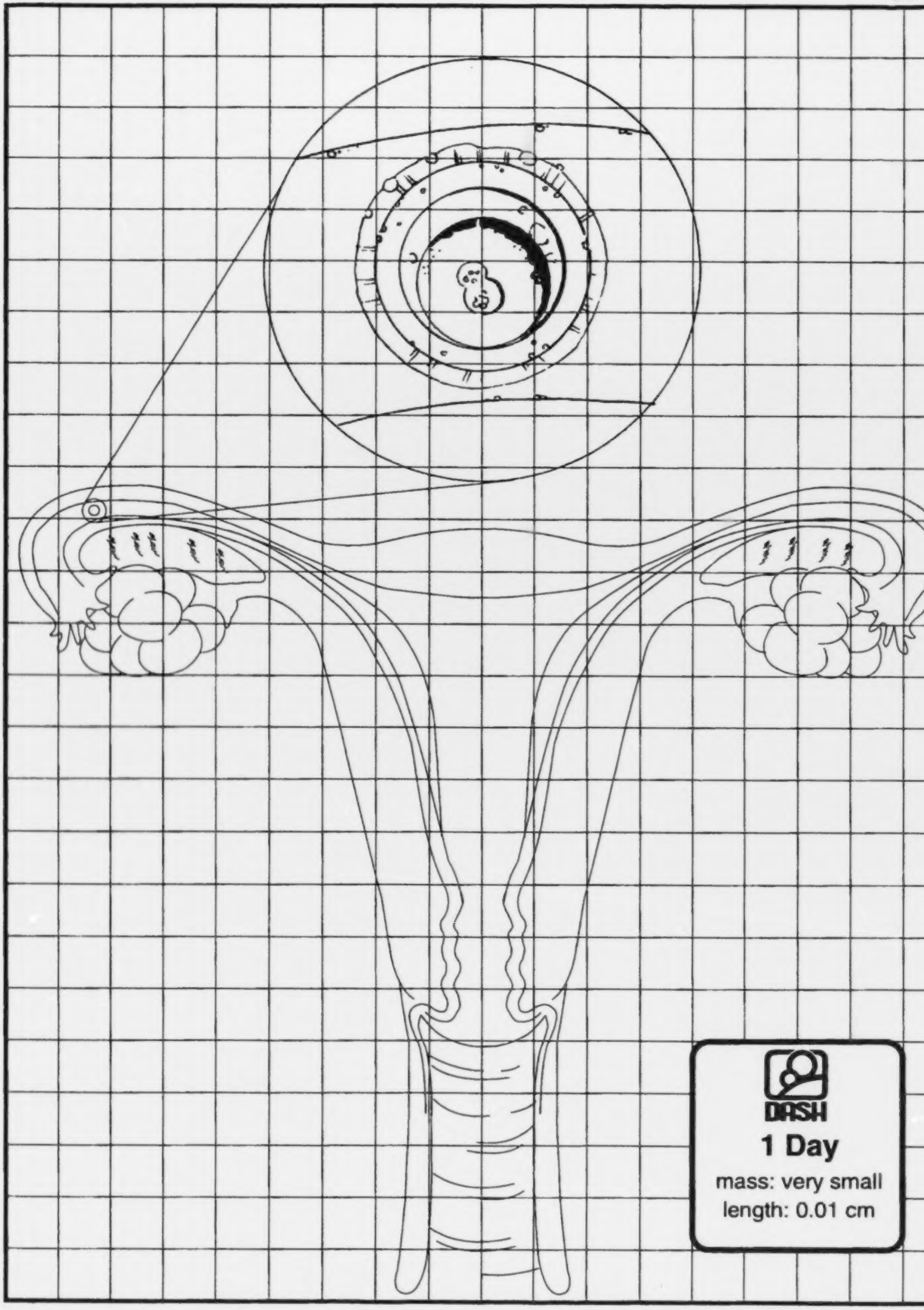
5. **Have the students reflect on the issues involved in pregnancy and giving birth to a healthy baby. Have them develop questions around these issues. Information can be obtained from outside speakers, research projects, guided field trips to a maternity ward of a hospital, or combinations of the above.**

   Help the students formulate questions around such topics as these:
   - The optimum years for reproduction and the prognosis for the health of a baby born to a mother who has not yet reached full maturity.
   - Special nutritional needs of a mother during pregnancy and after.
   - How a parent's use of tobacco, alcohol, and drugs might affect a developing baby.
   - Possible effects of a parent's sexually transmitted disease on a developing baby.
   - What it takes to raise a baby in terms of money and other resources.

EXTENSION

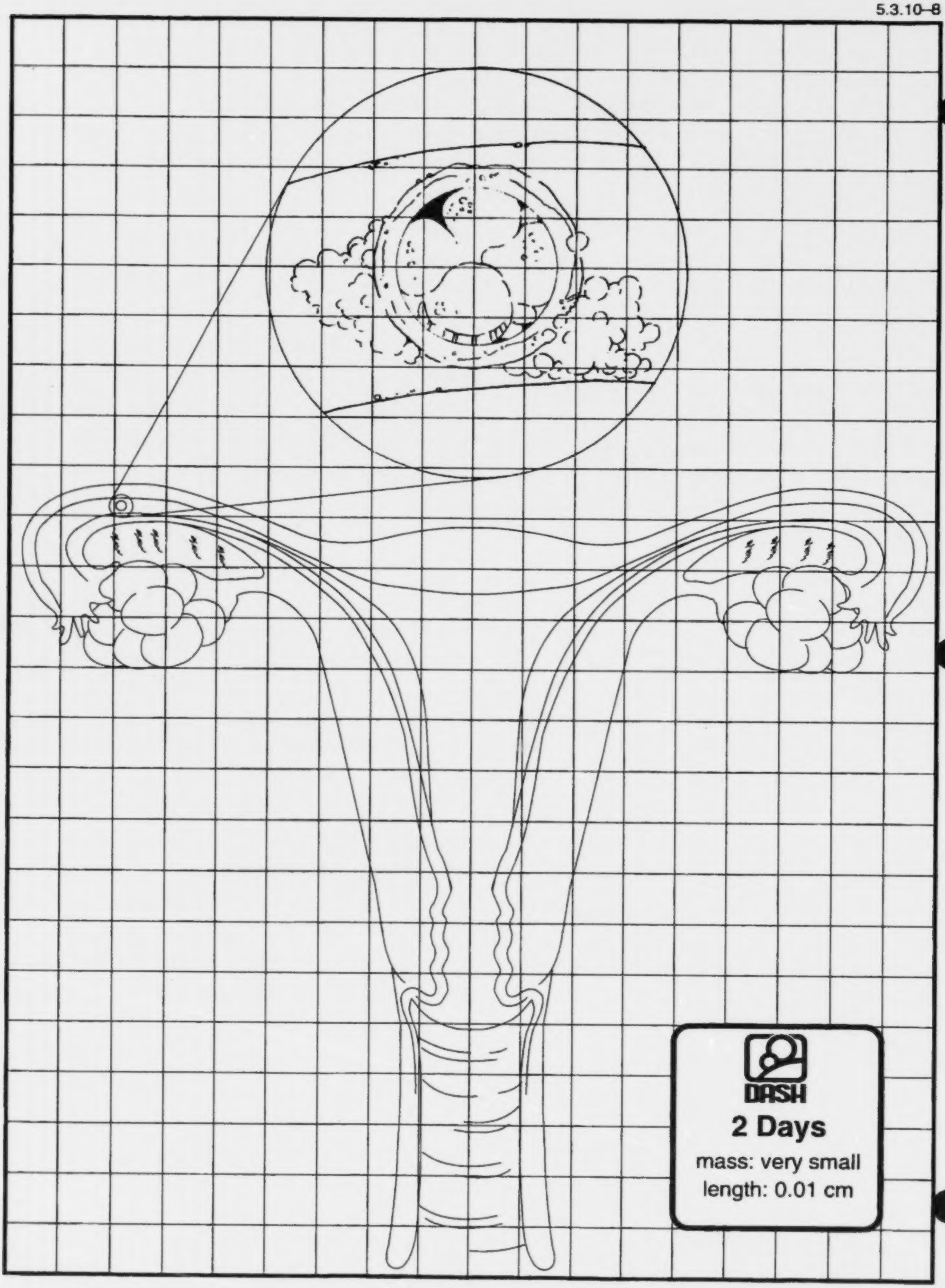
Have the students
- Look at videotapes showing the development of the fetus.

ILLUSTRATIONS



1 Day

mass: very small
length: 0.01 cm

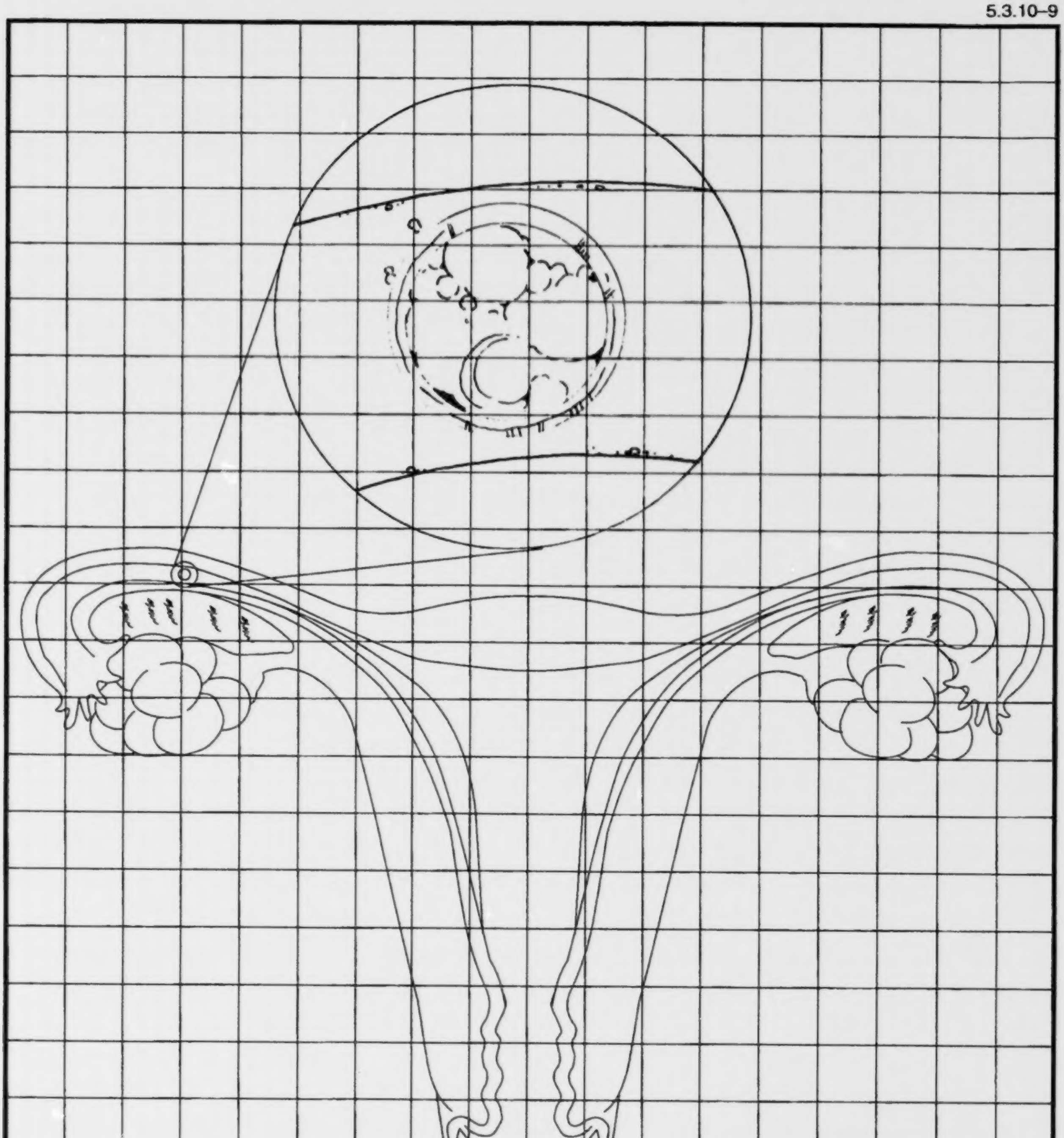


DASH

2 Days

mass: very small

length: 0.01 cm

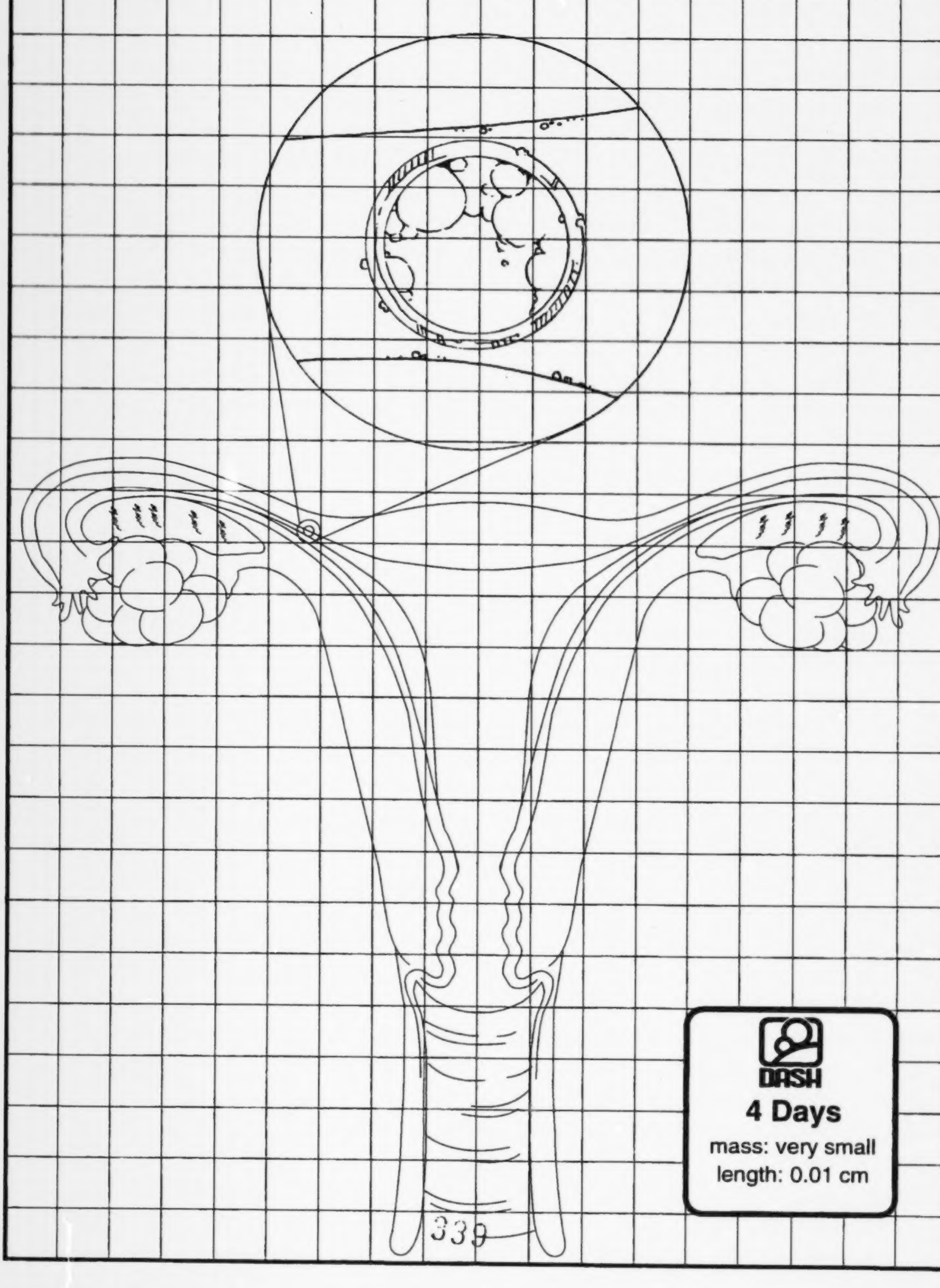


DASH

3 Days

mass: very small

length: 0.01 cm



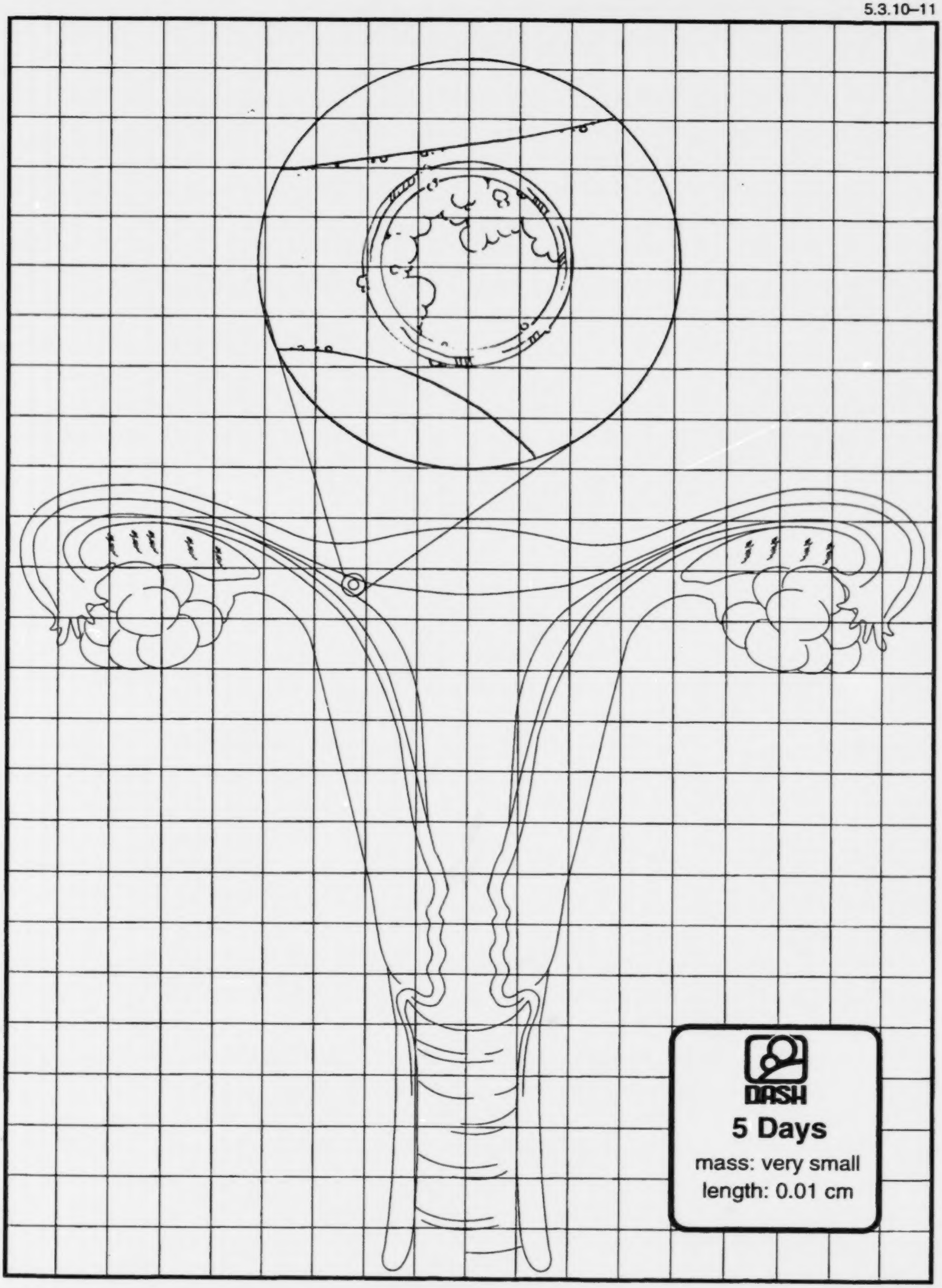
DASH

4 Days

mass: very small

length: 0.01 cm

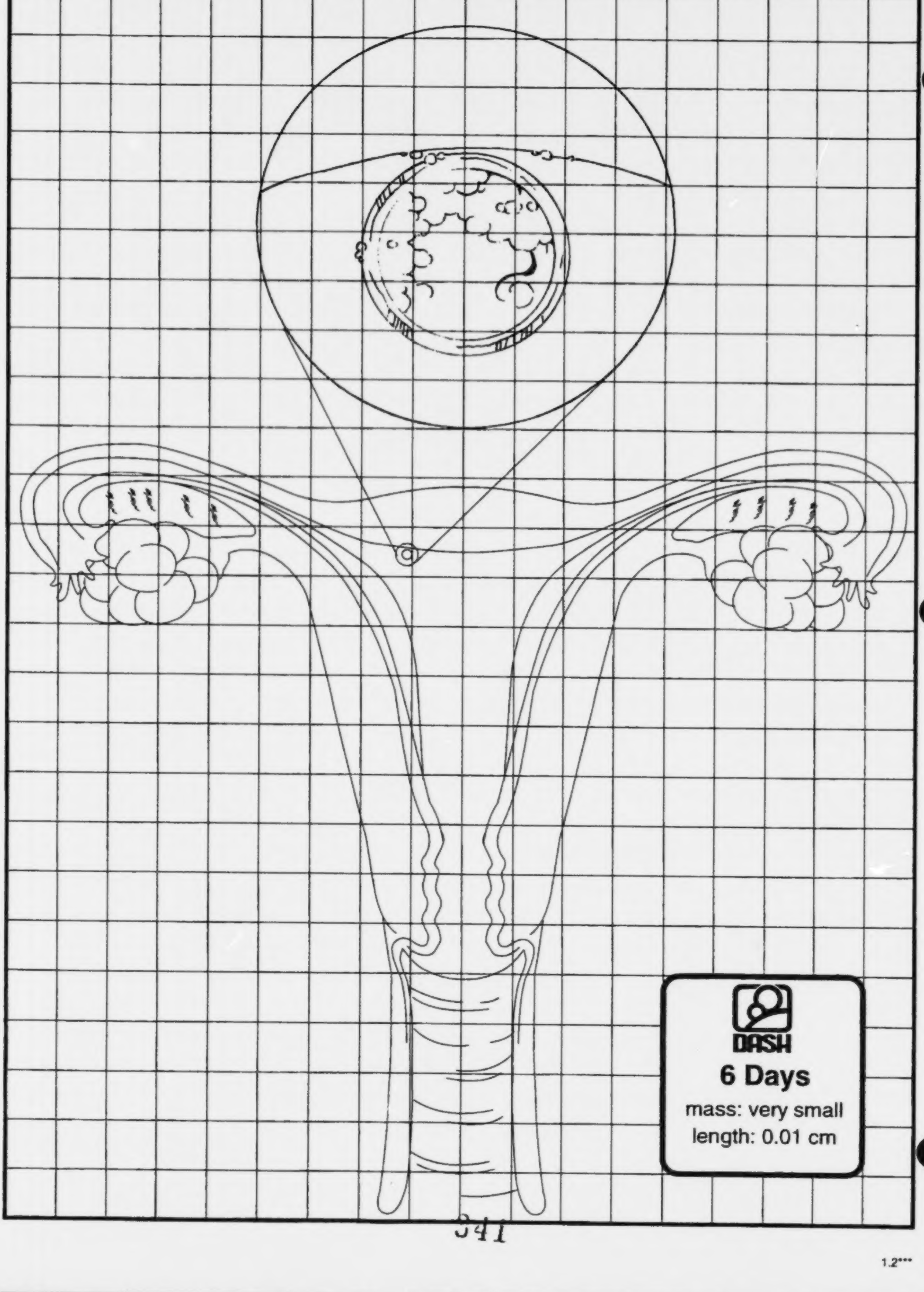
339



DASH

5 Days

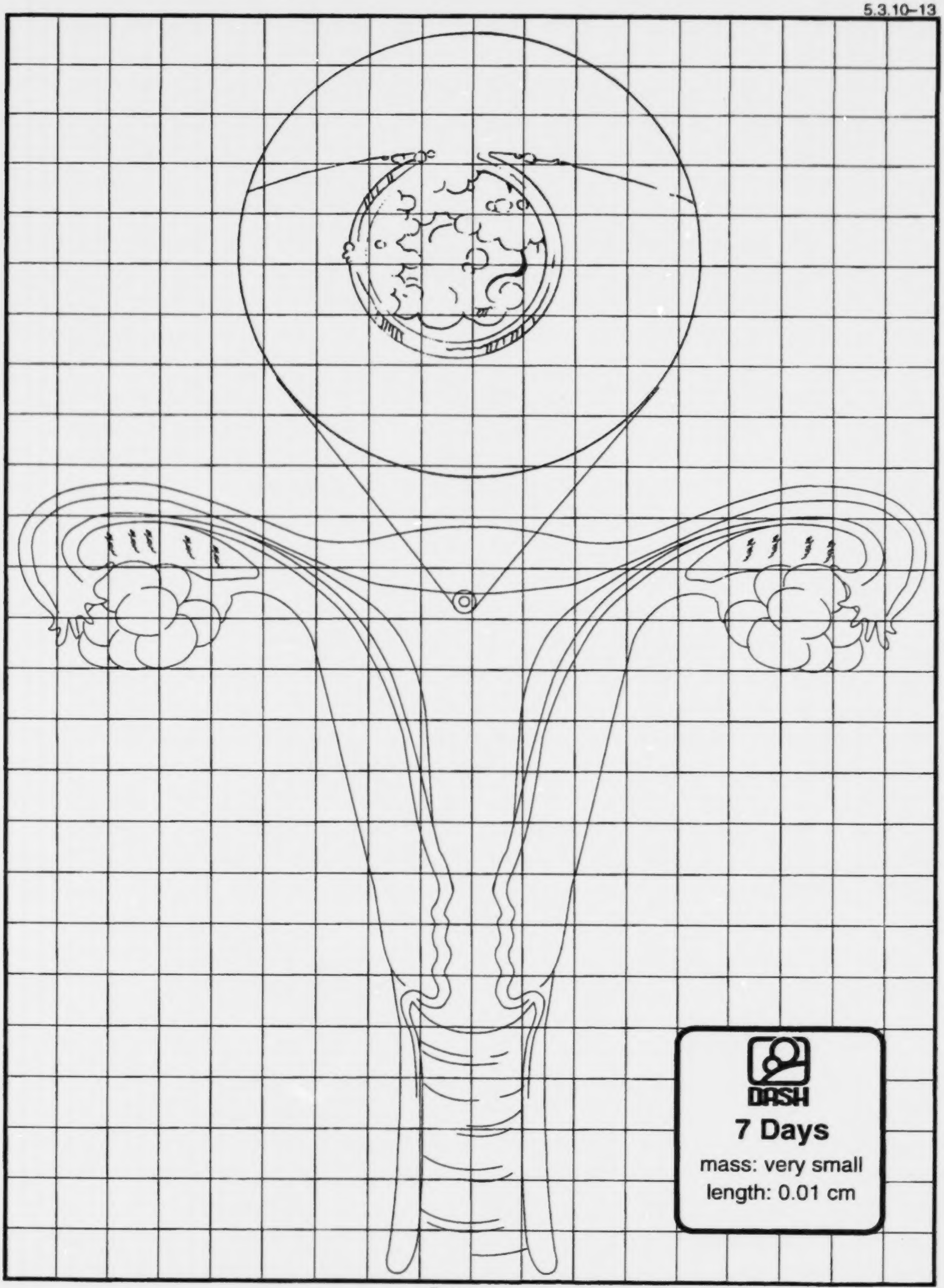
mass: very small
length: 0.01 cm



DASH

6 Days

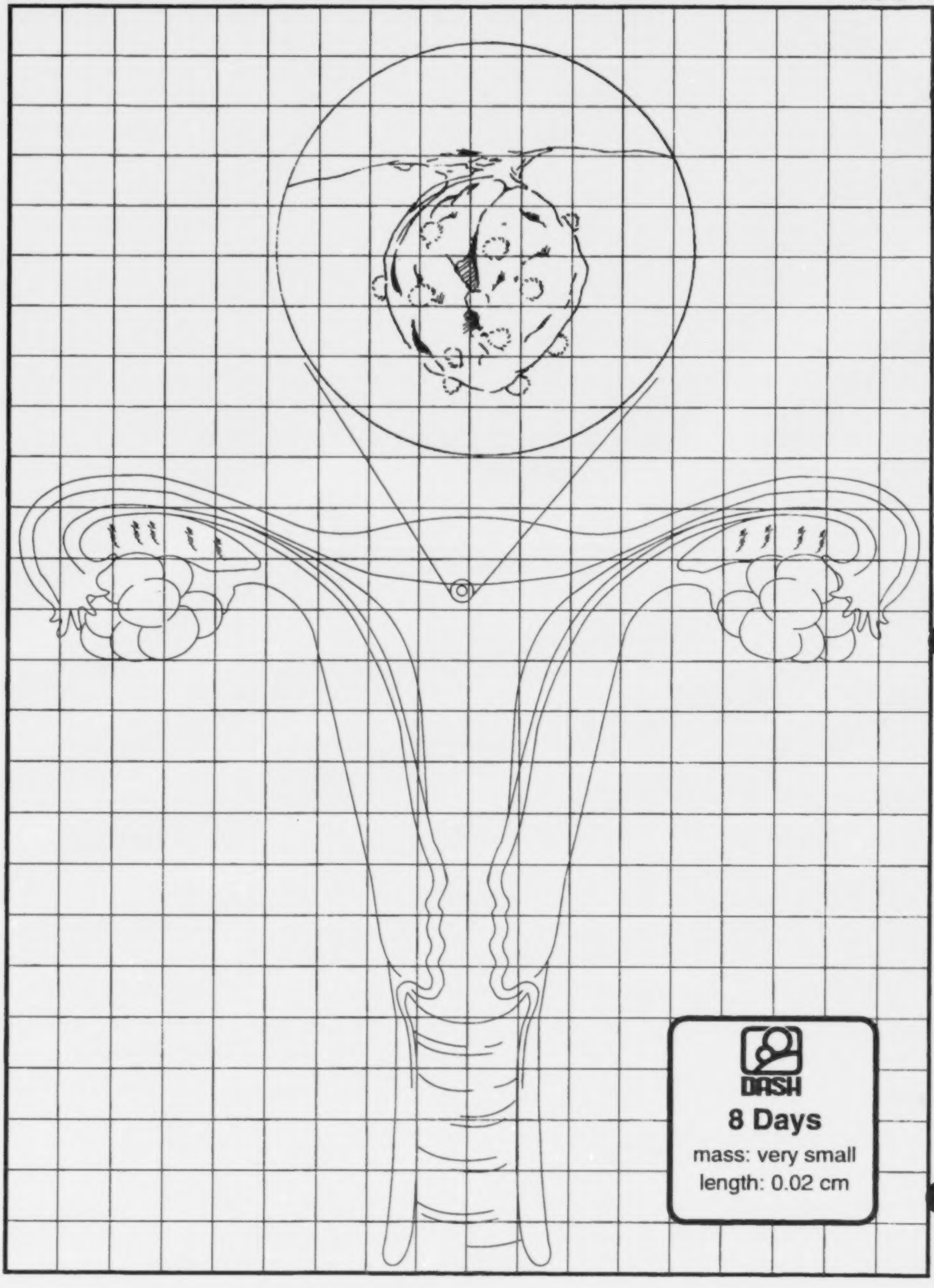
mass: very small
length: 0.01 cm



DASH

7 Days

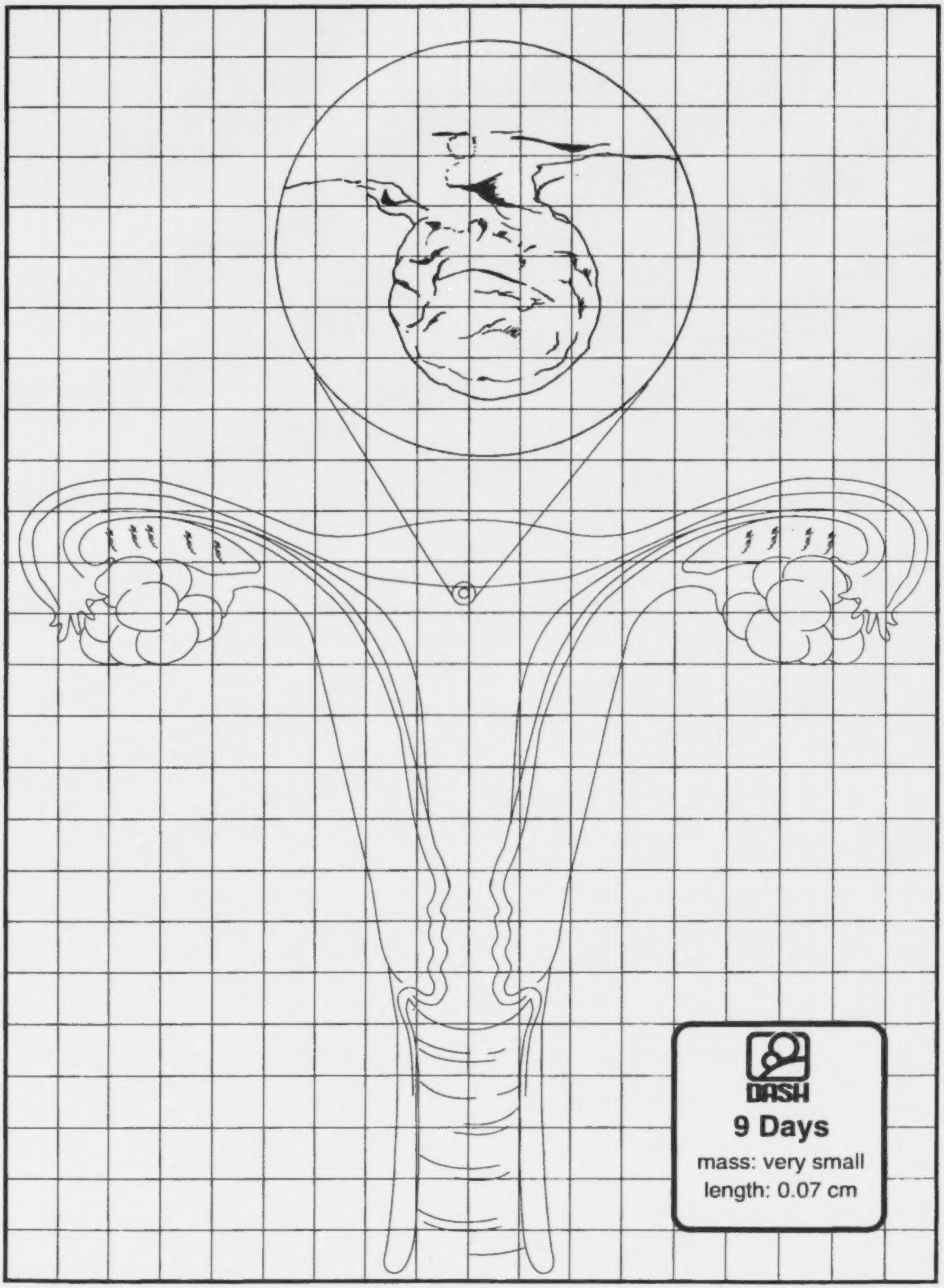
mass: very small
length: 0.01 cm



DASH

8 Days

mass: very small
length: 0.02 cm

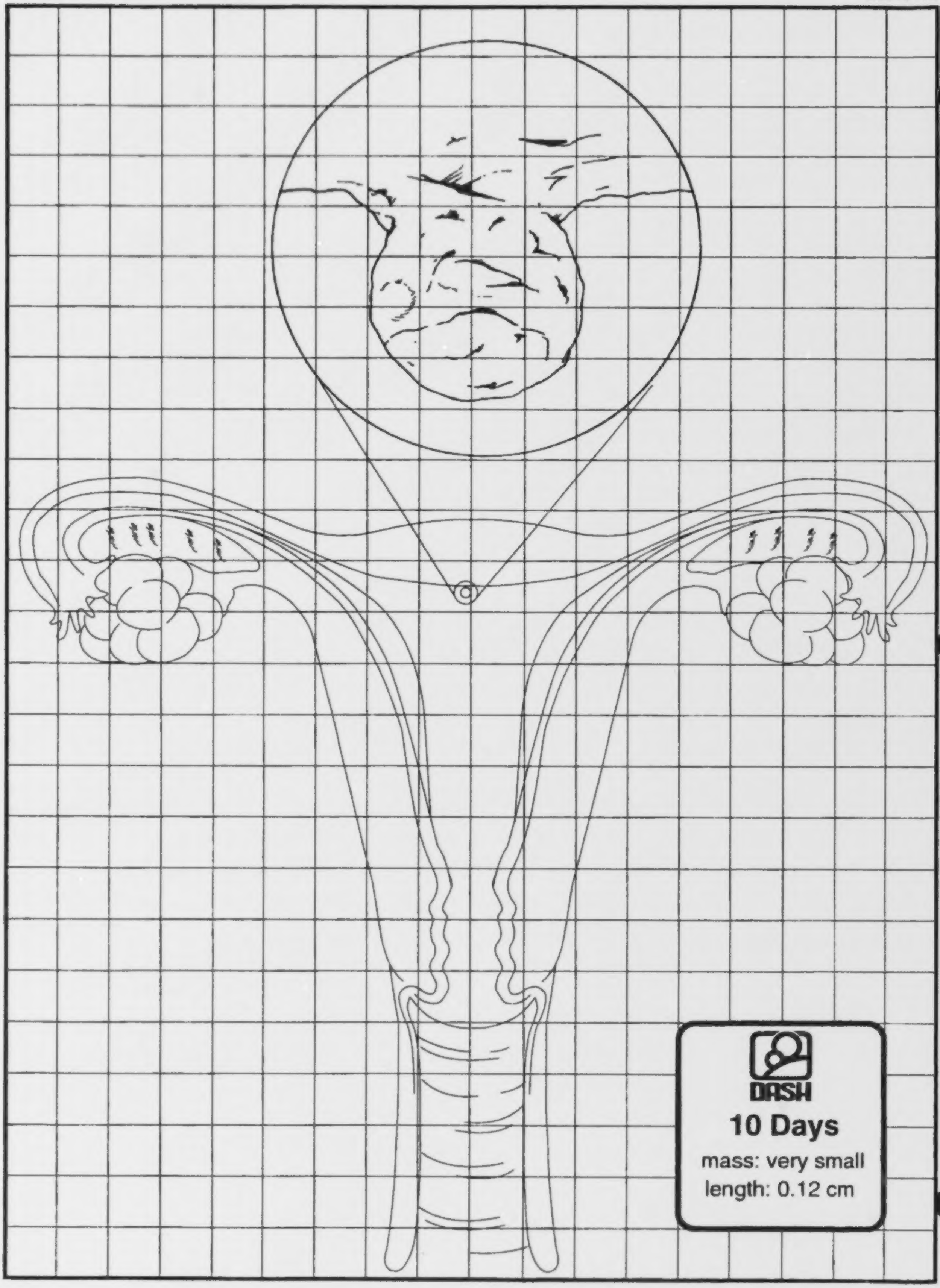


DASH

9 Days

mass: very small

length: 0.07 cm

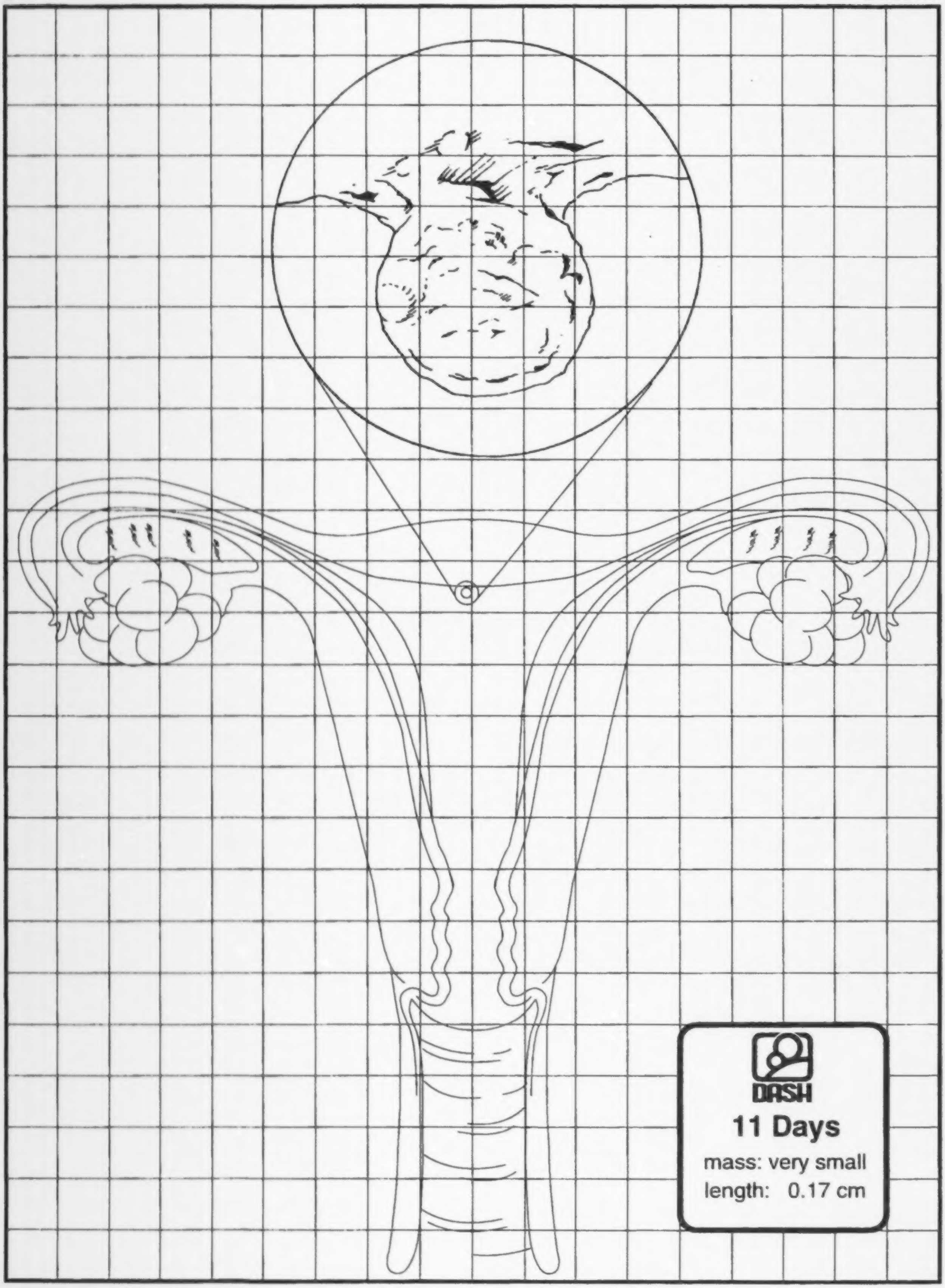


DASH

10 Days

mass: very small

length: 0.12 cm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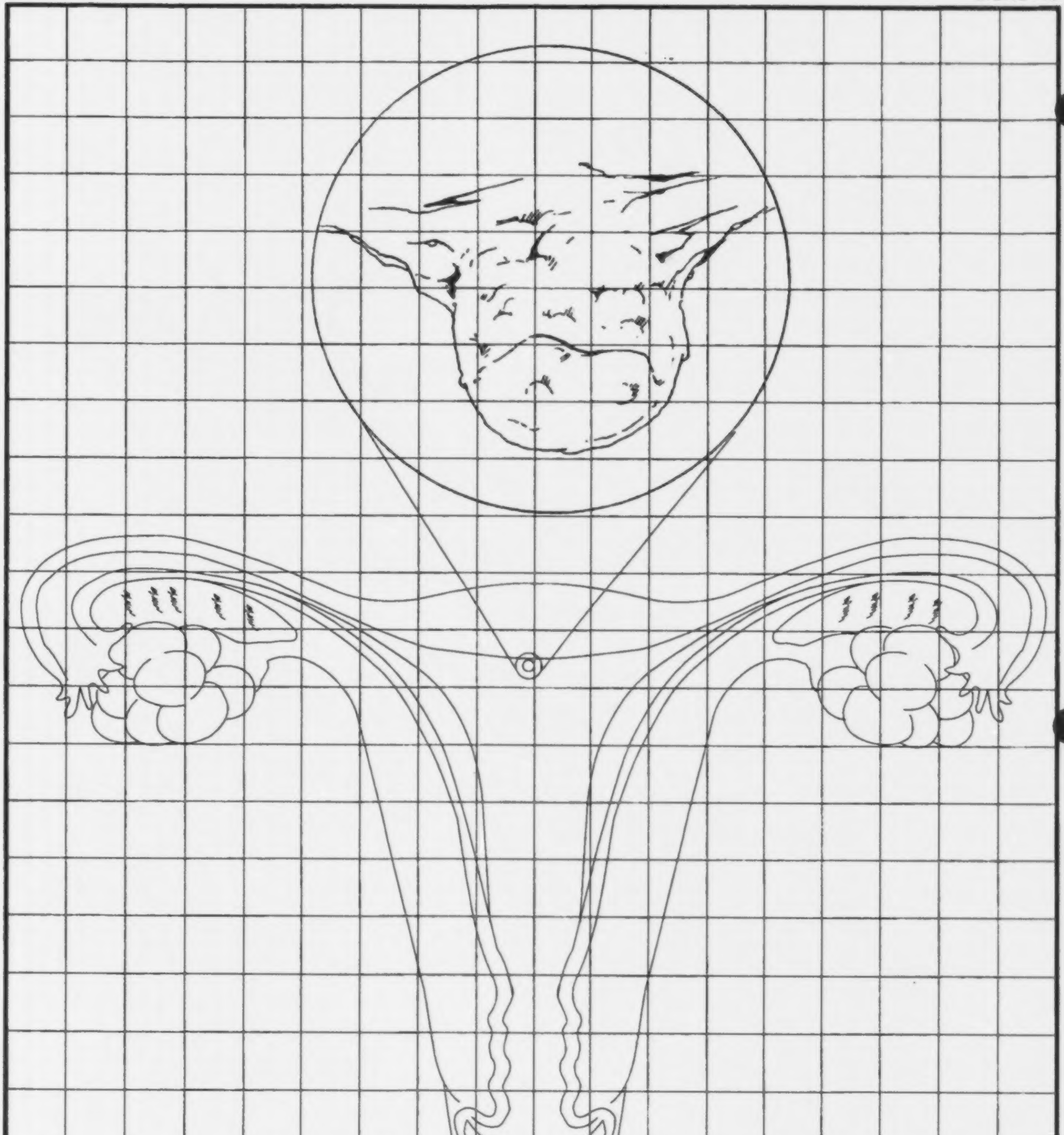
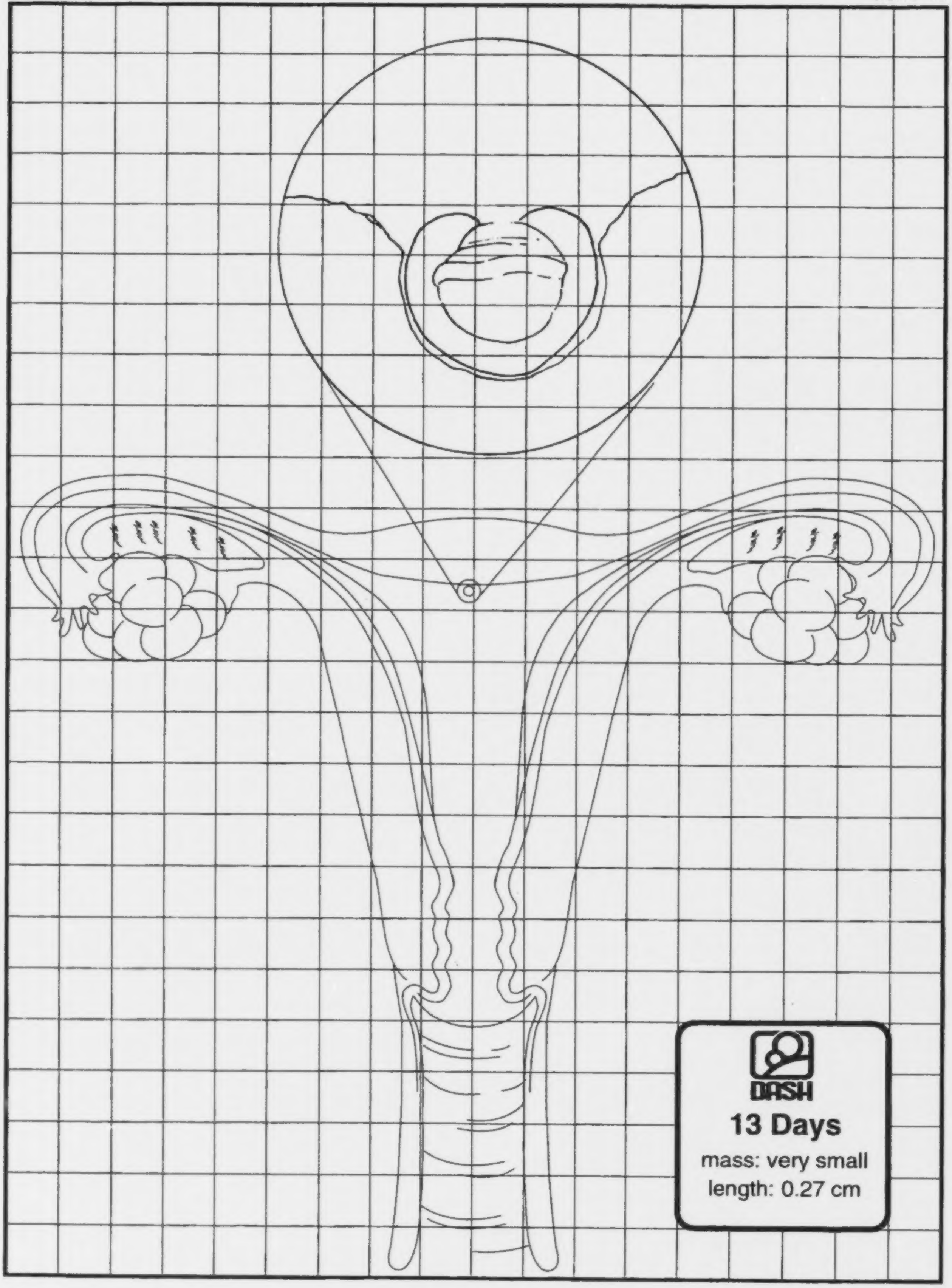
11 Days
mass: very small
length: 0.17 cm



DASH

12 Days

mass: very small
length: 0.22 cm

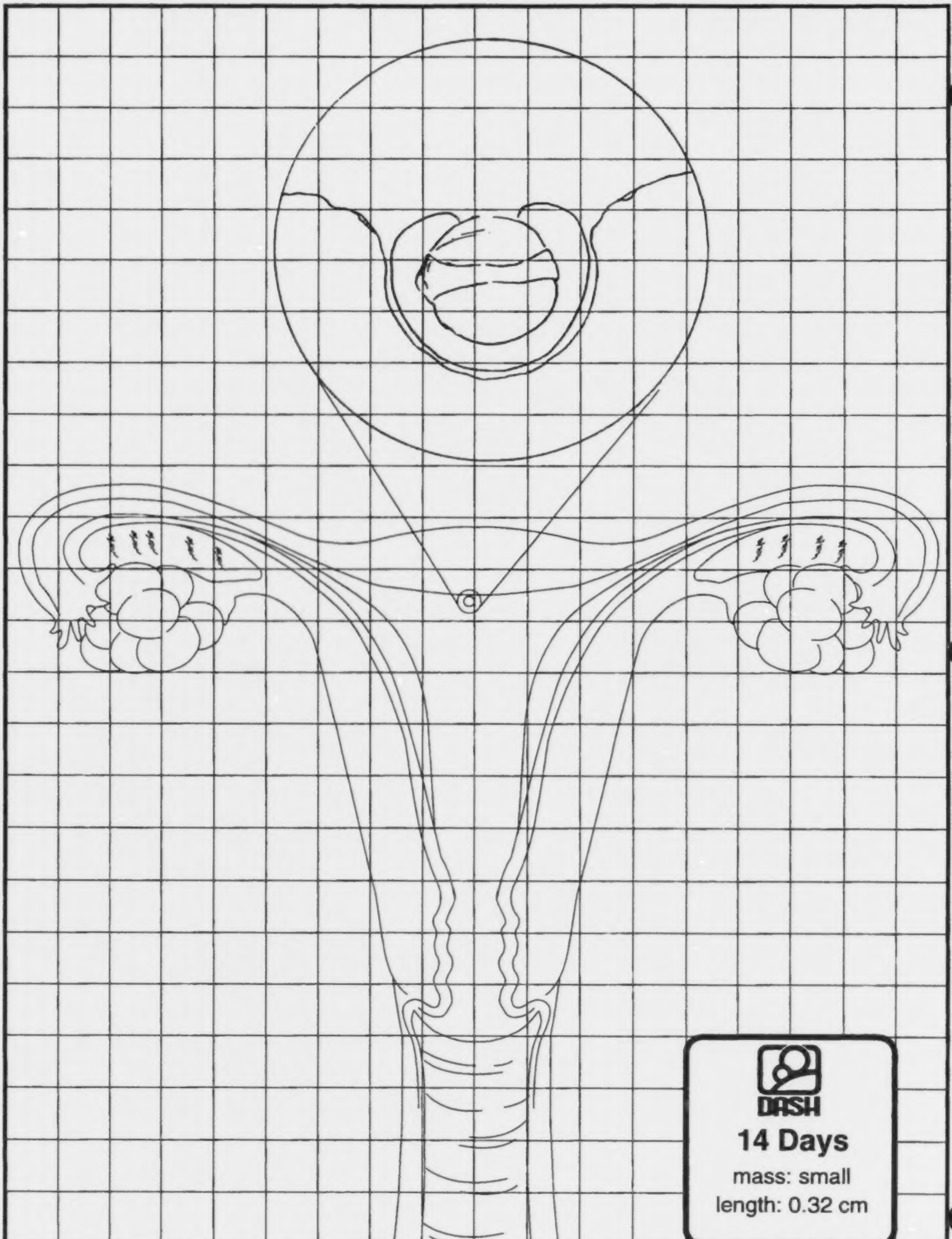


DASH

13 Days

mass: very small

length: 0.27 cm

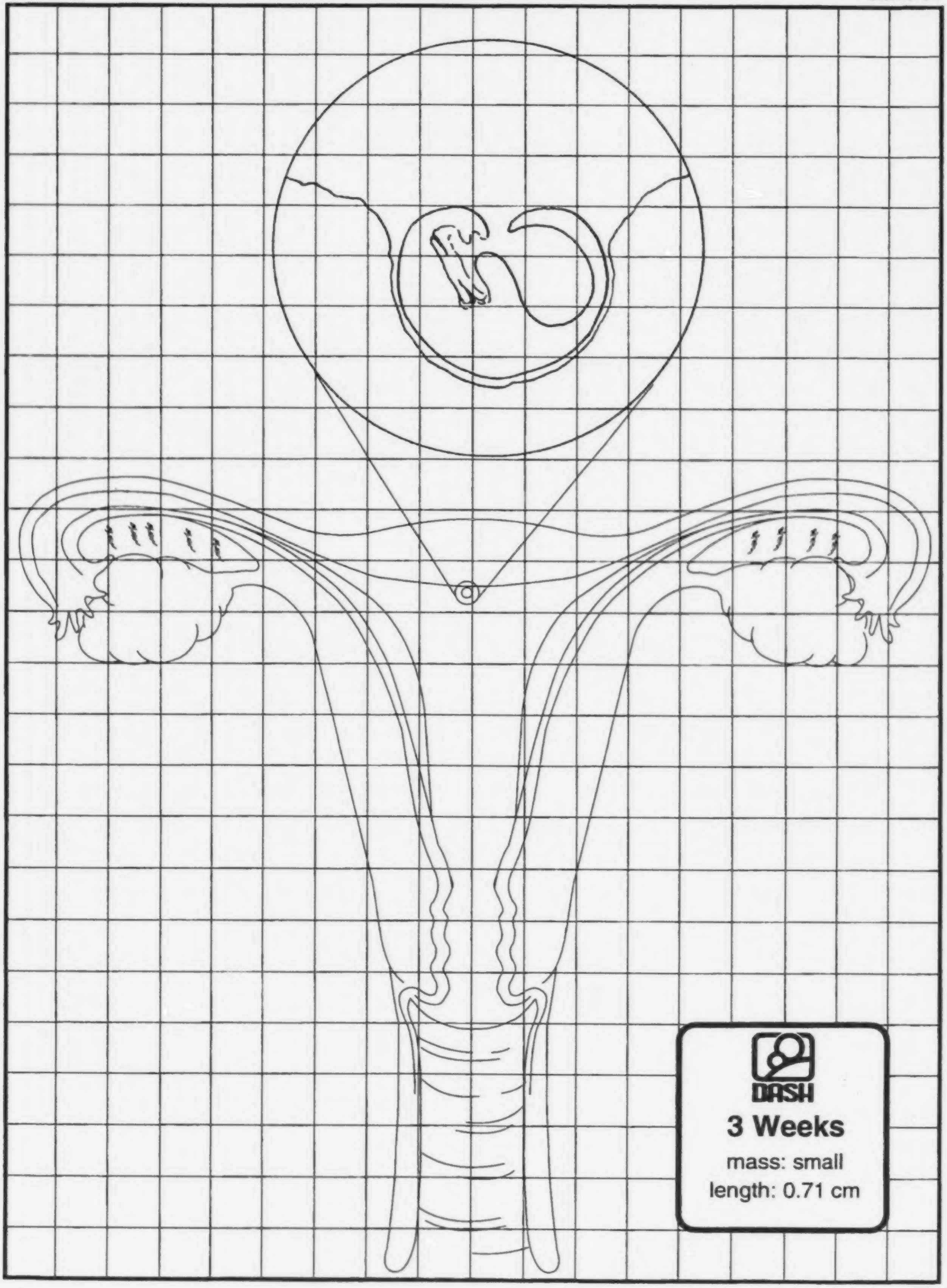


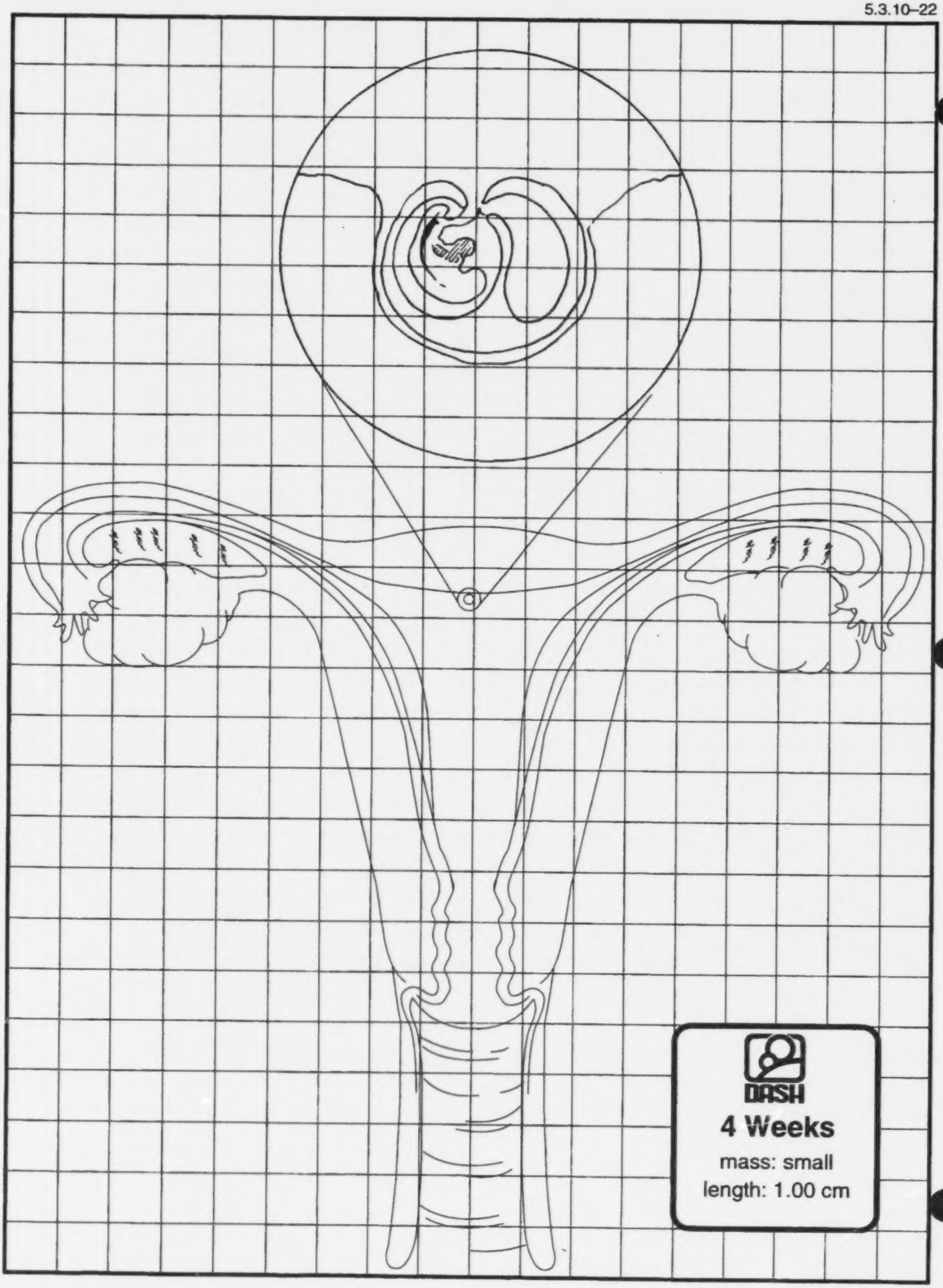
DASH

14 Days

mass: small

length: 0.32 cm


DASH
3 Weeks
mass: small
length: 0.71 cm



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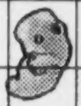
4 Weeks

mass: small

length: 1.00 cm



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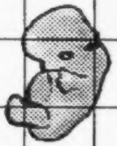
5 weeks

mass: small

length: 1.40 cm



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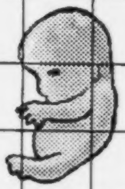
6 weeks

mass: 1.20 g

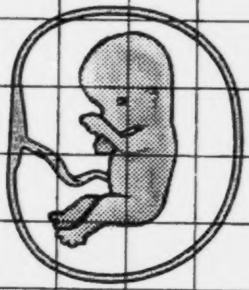
length: 1.90 cm



DASH

7 weeks

mass: 1.60 g
length: 2.30 cm



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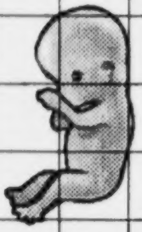
8 weeks

*mass: 2.00 g

length: 3.50 cm

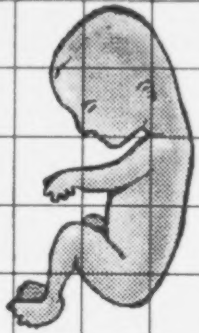
* does not include placenta



DASH

10 weeks

mass: 5.00 g
length: 5.00 cm

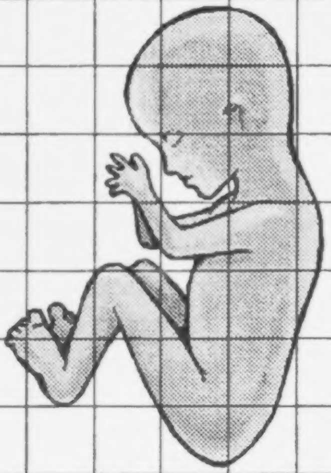


DASH

12 weeks

mass: 16.00 g

length: 7.50 cm



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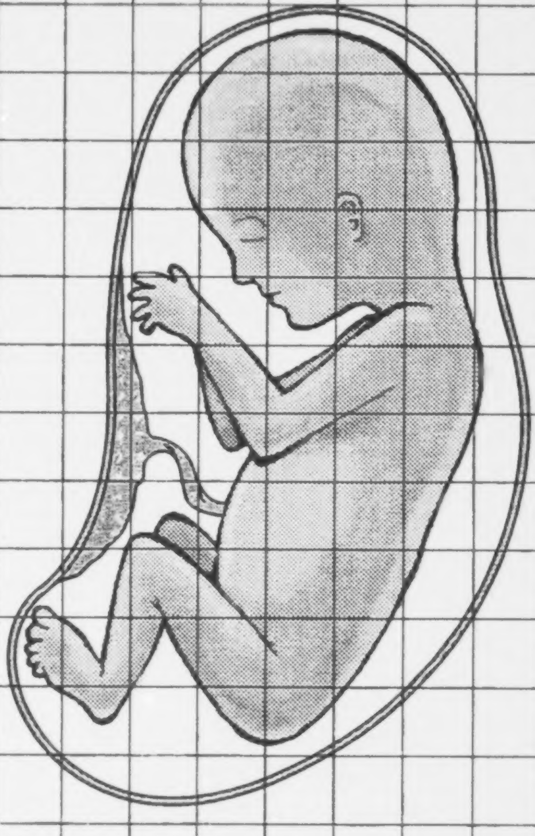
14 weeks

mass: 80.00 g

length: 12.00 cm



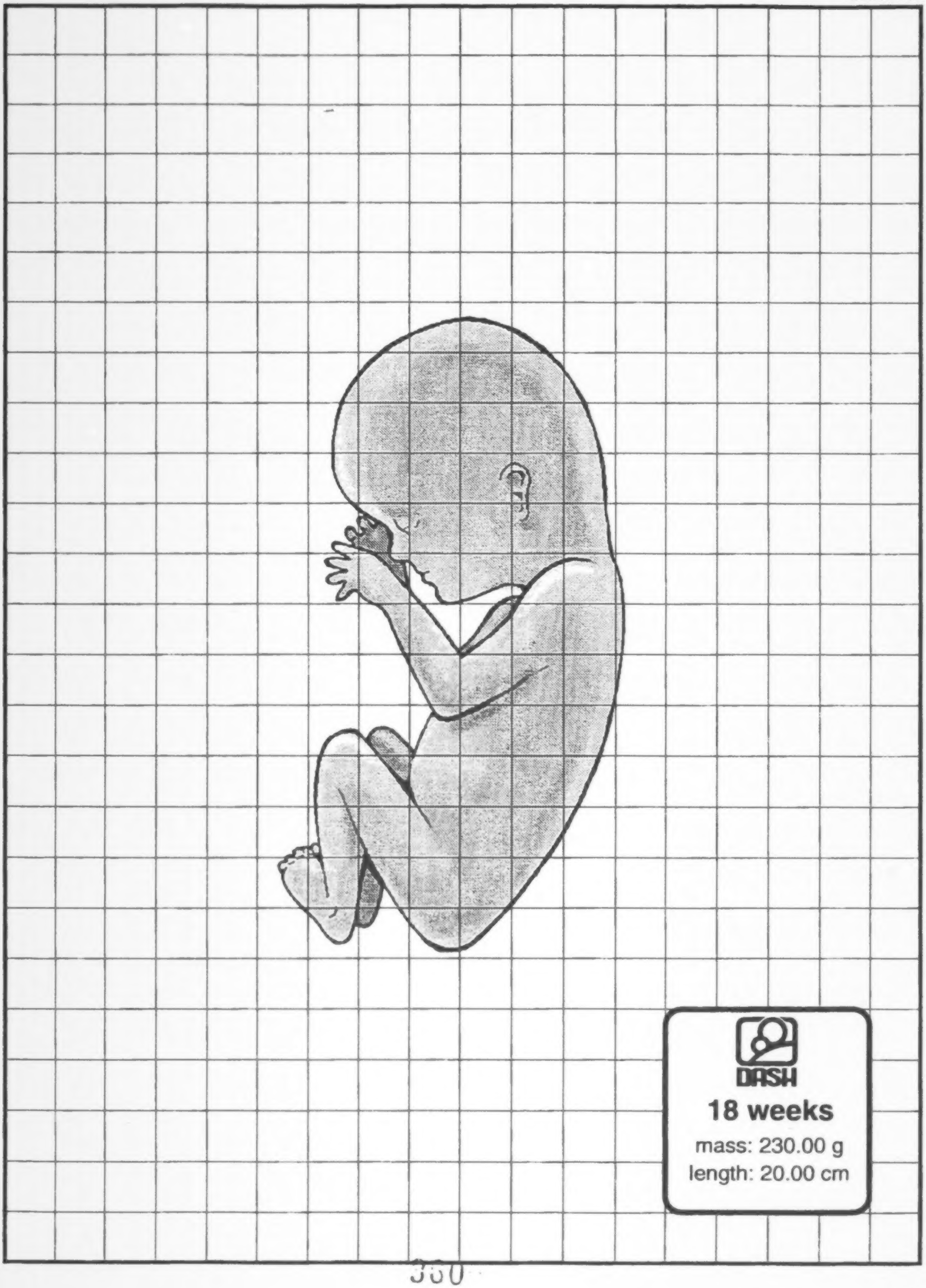
DASH

16 weeks

*mass: 140.00 g

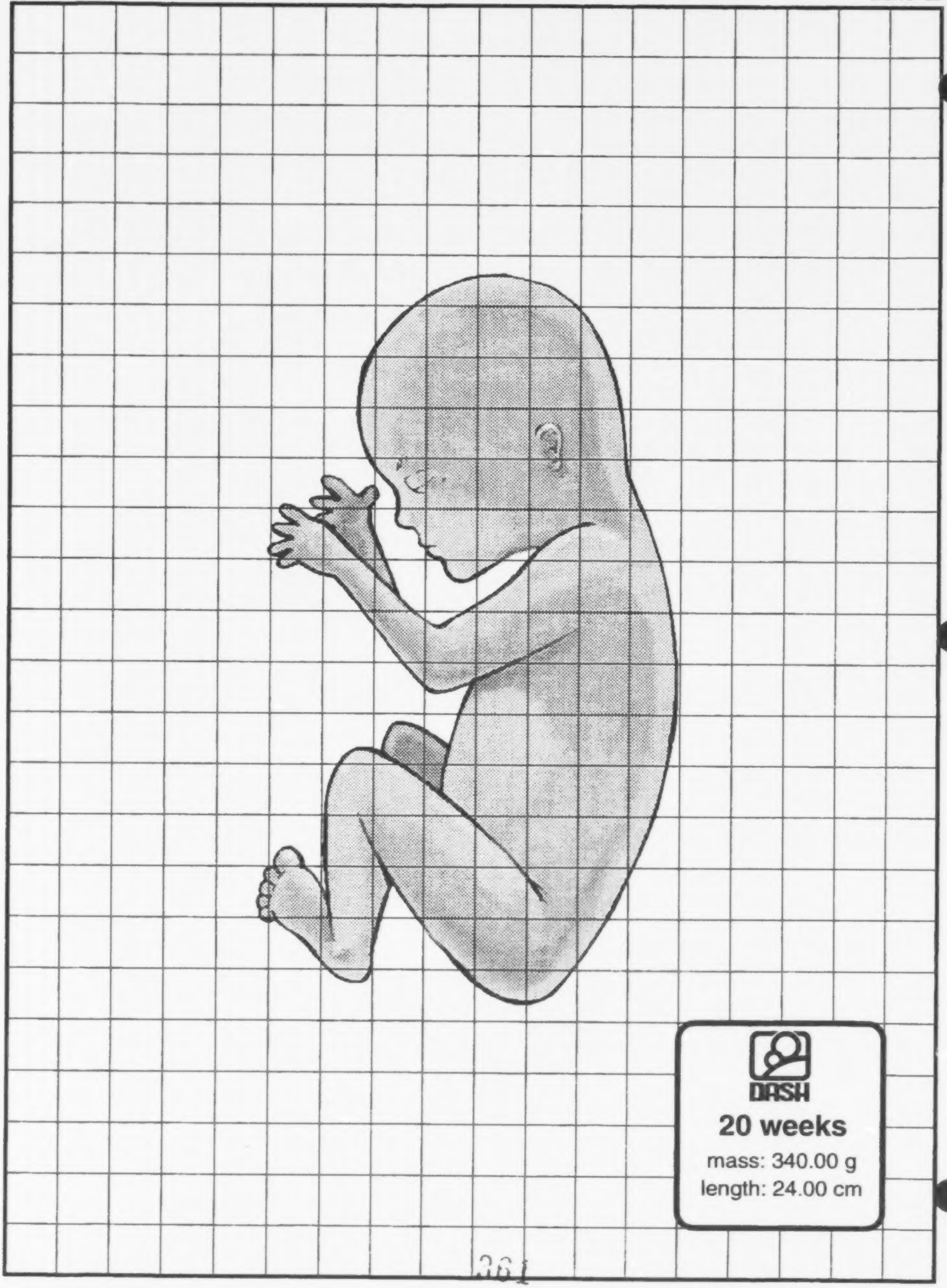
length: 16.00 cm

* does not include placenta



18 weeks

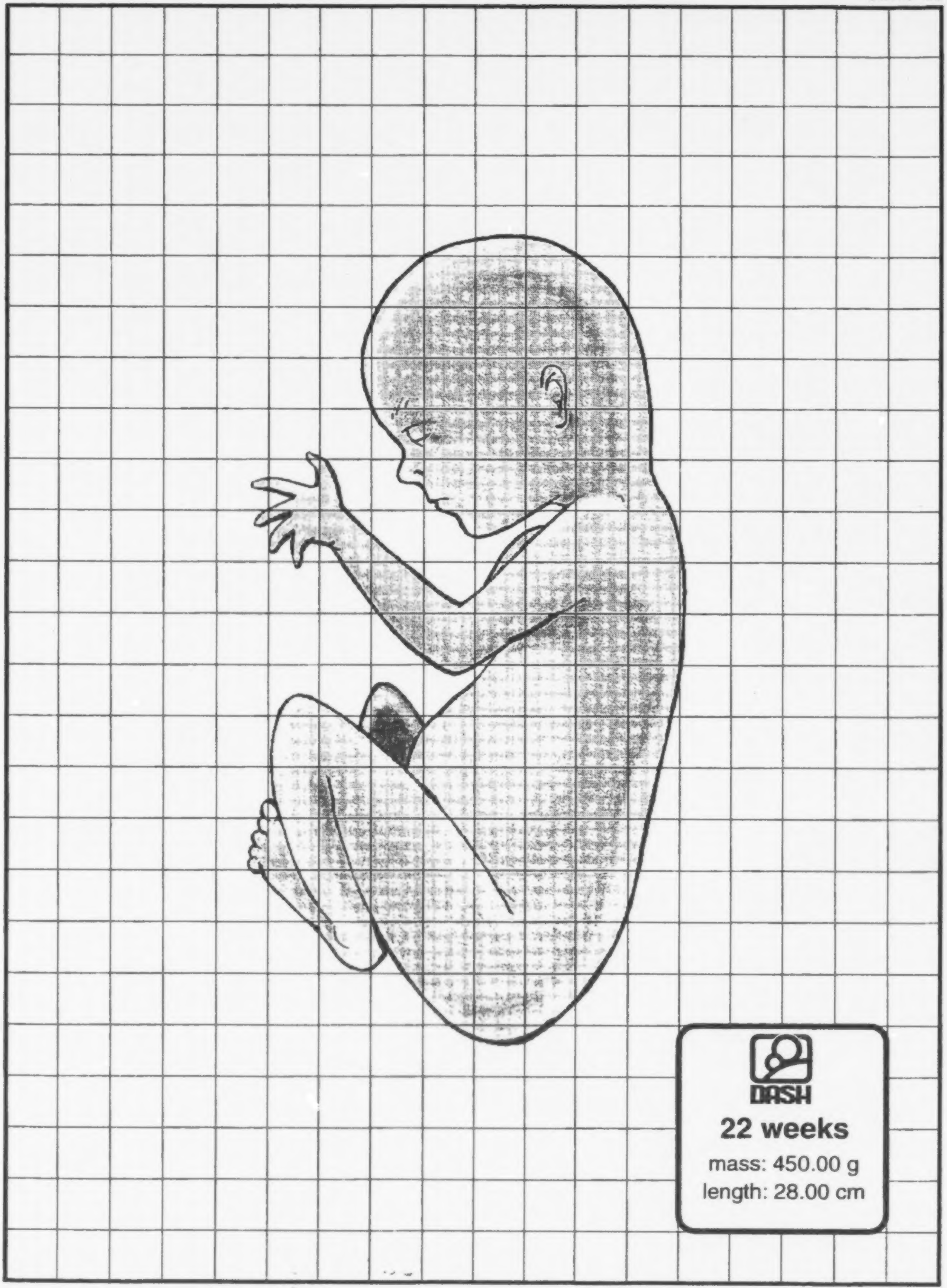
mass: 230.00 g
length: 20.00 cm

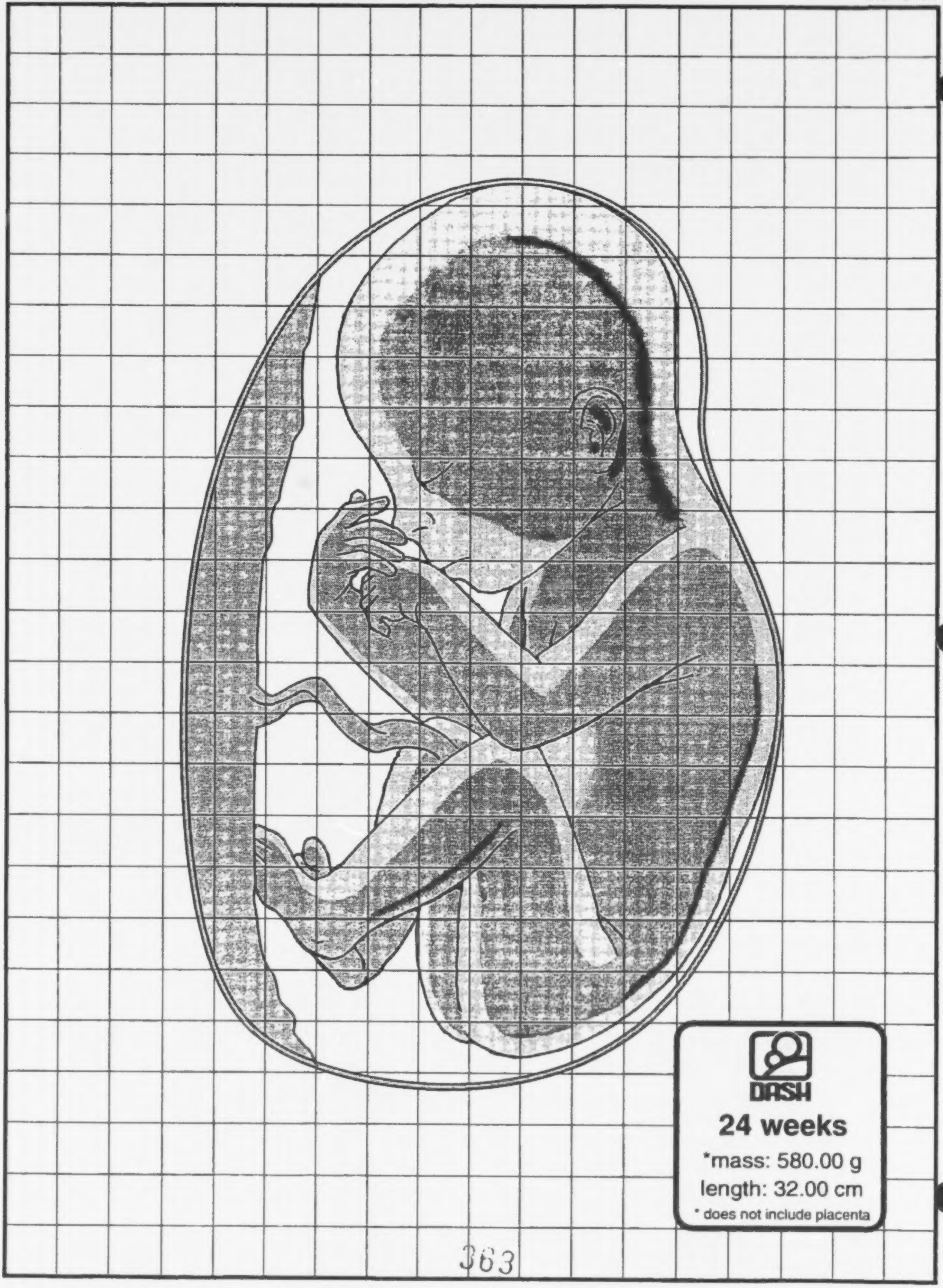


DASH

20 weeks

mass: 340.00 g
length: 24.00 cm


DASH
22 weeks
mass: 450.00 g
length: 28.00 cm



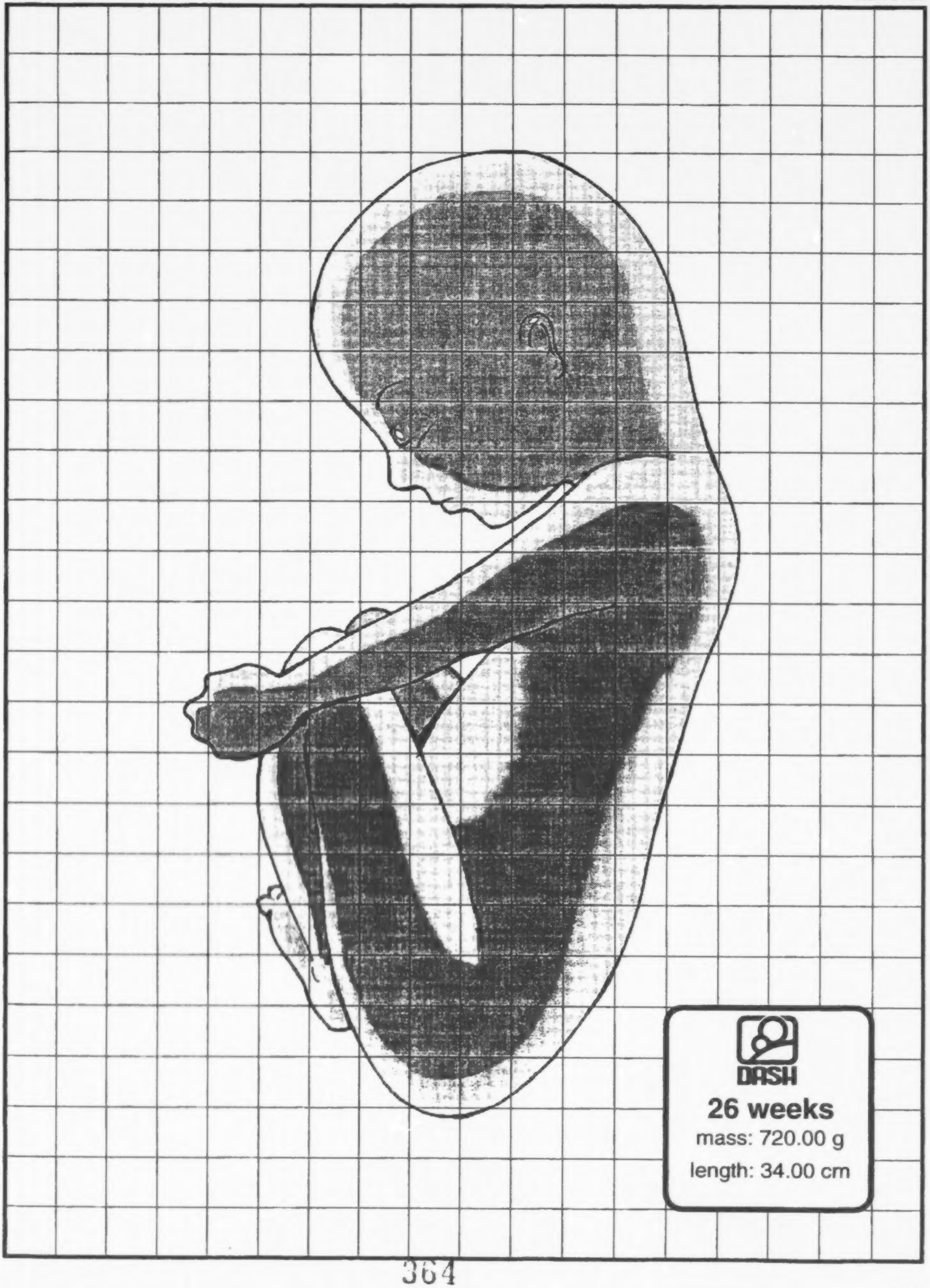
24 weeks

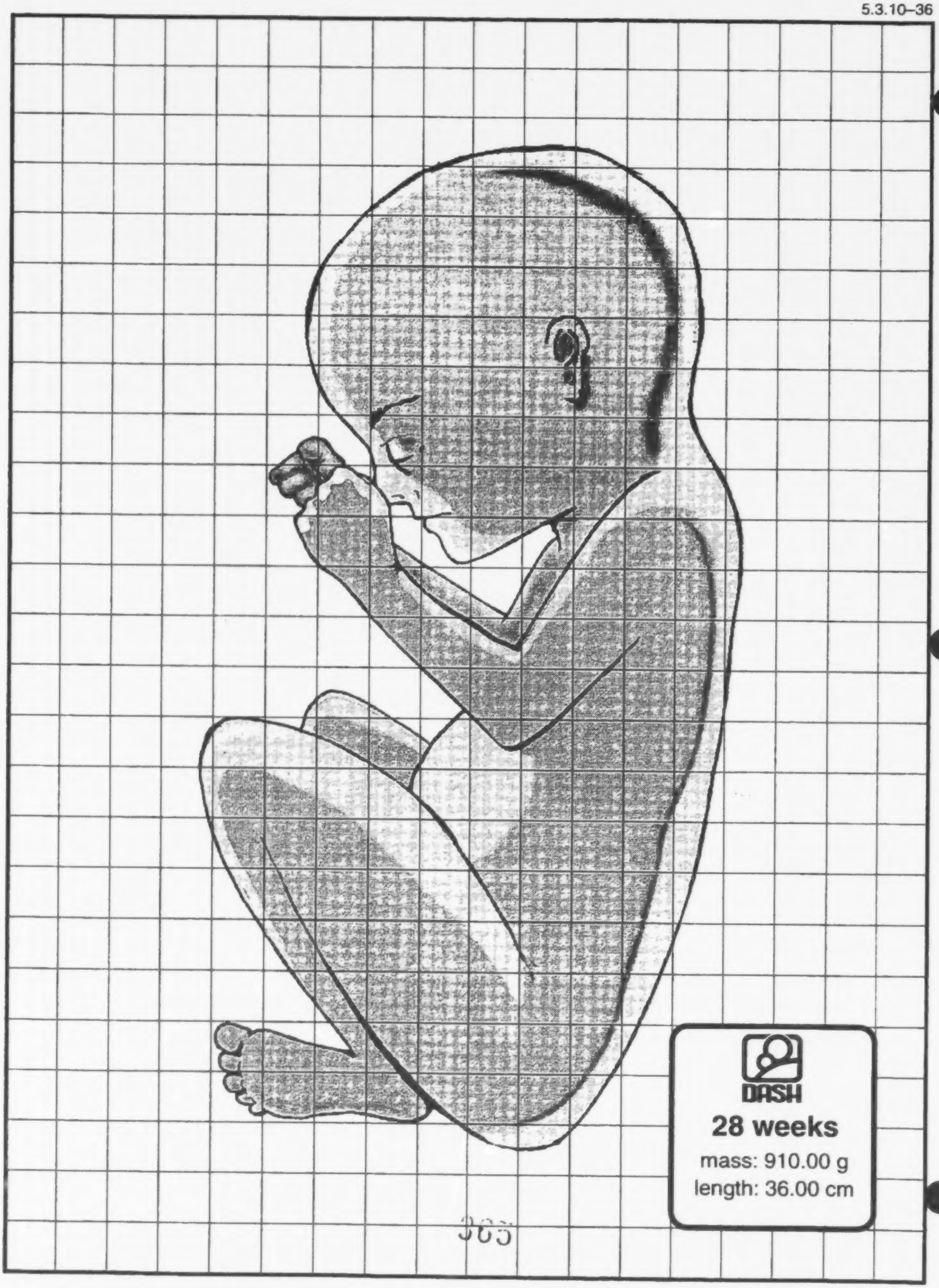
*mass: 580.00 g

length: 32.00 cm

* does not include placenta

363


DASH
26 weeks
mass: 720.00 g
length: 34.00 cm

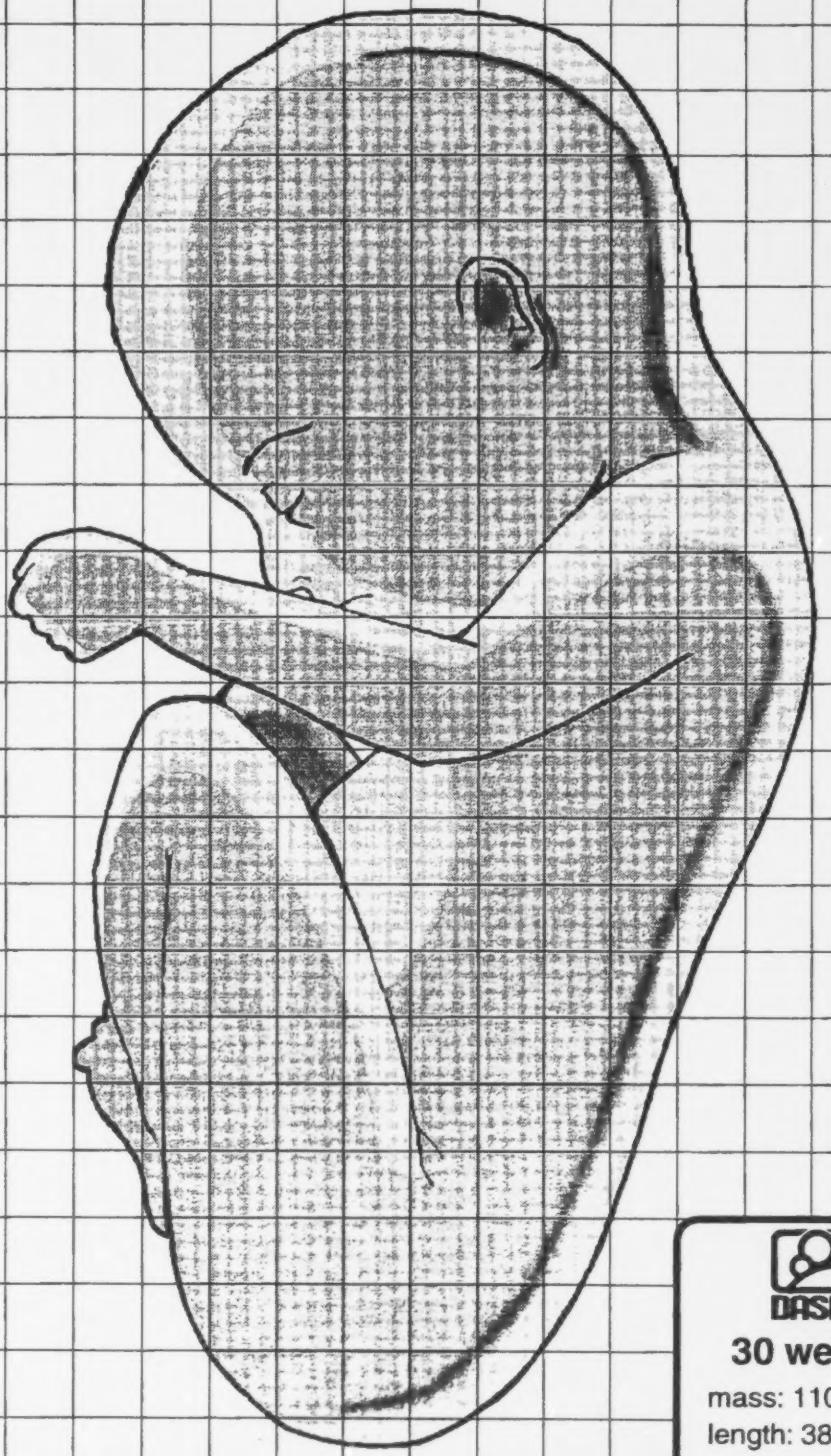


DASH

28 weeks

mass: 910.00 g

length: 36.00 cm

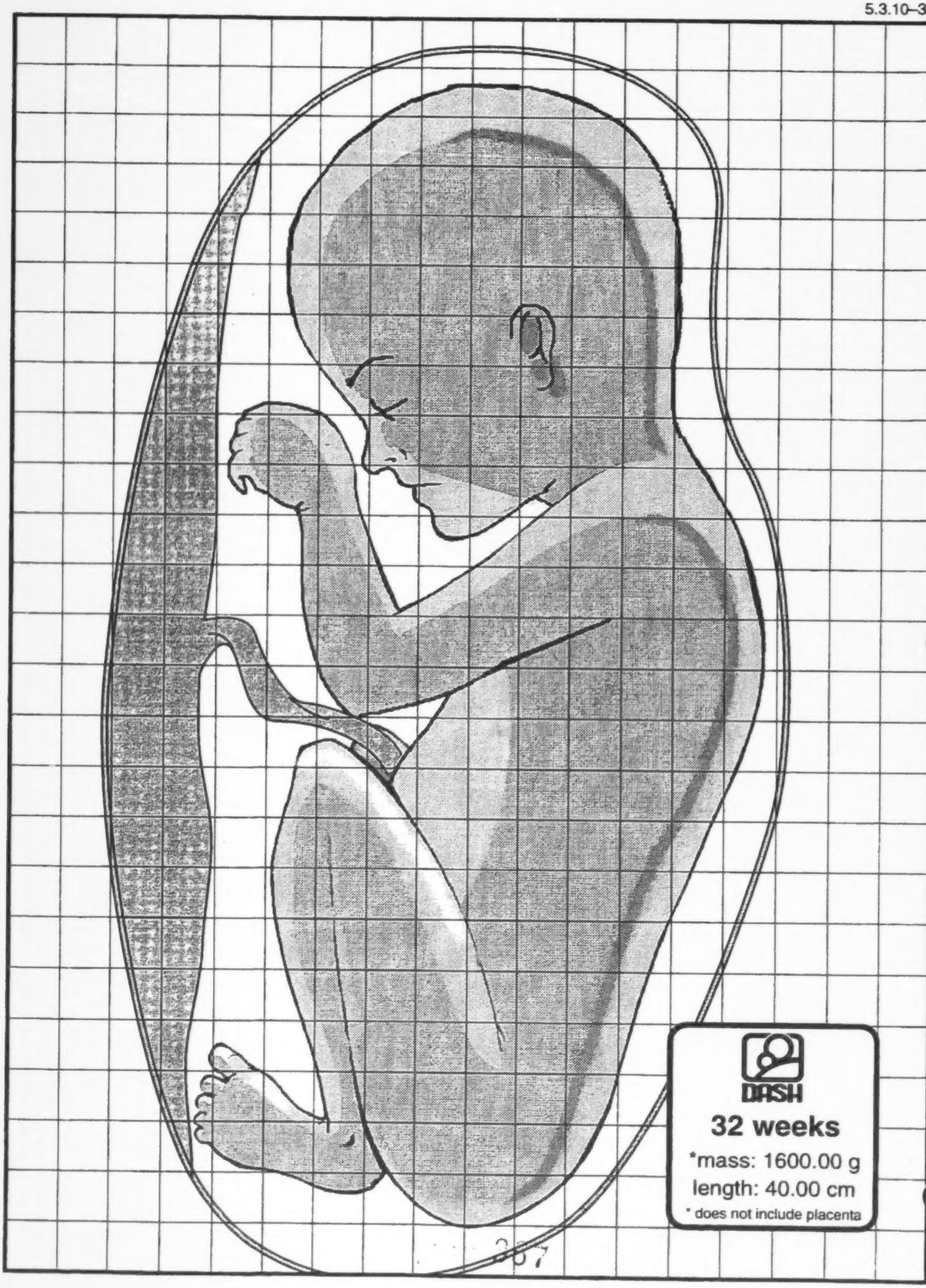


DASH

30 weeks

mass: 1100.00 g

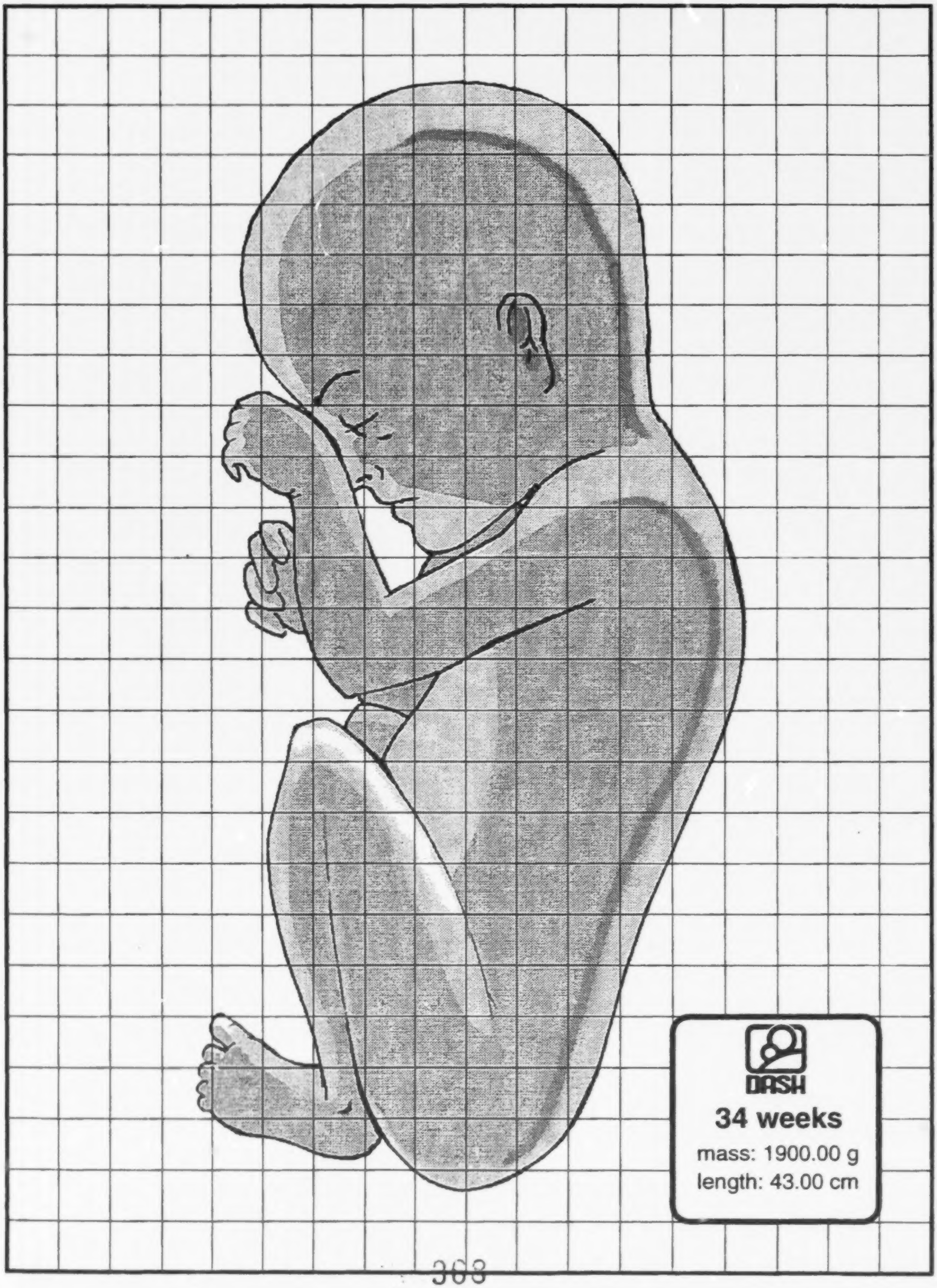
length: 38.00 cm

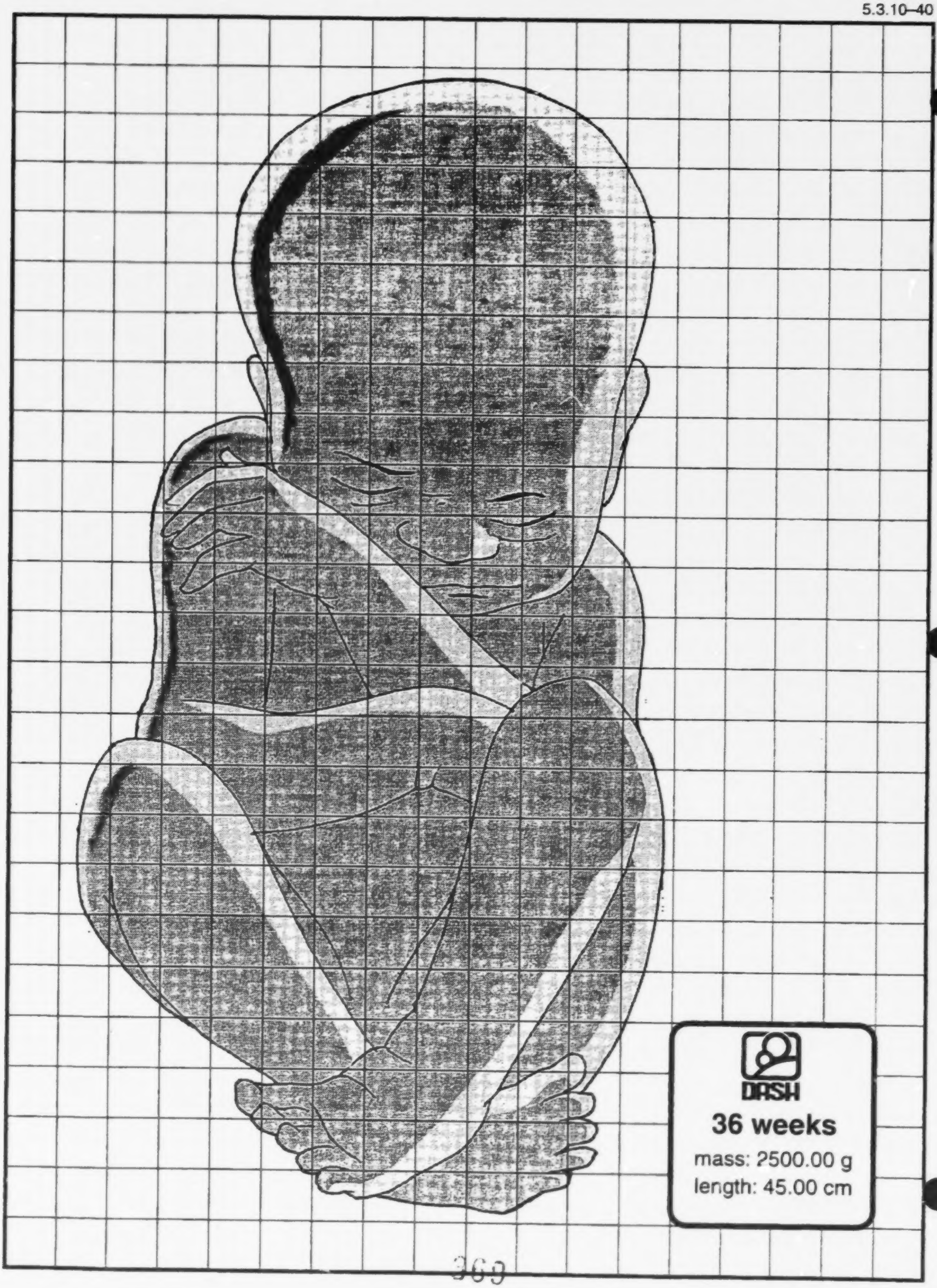


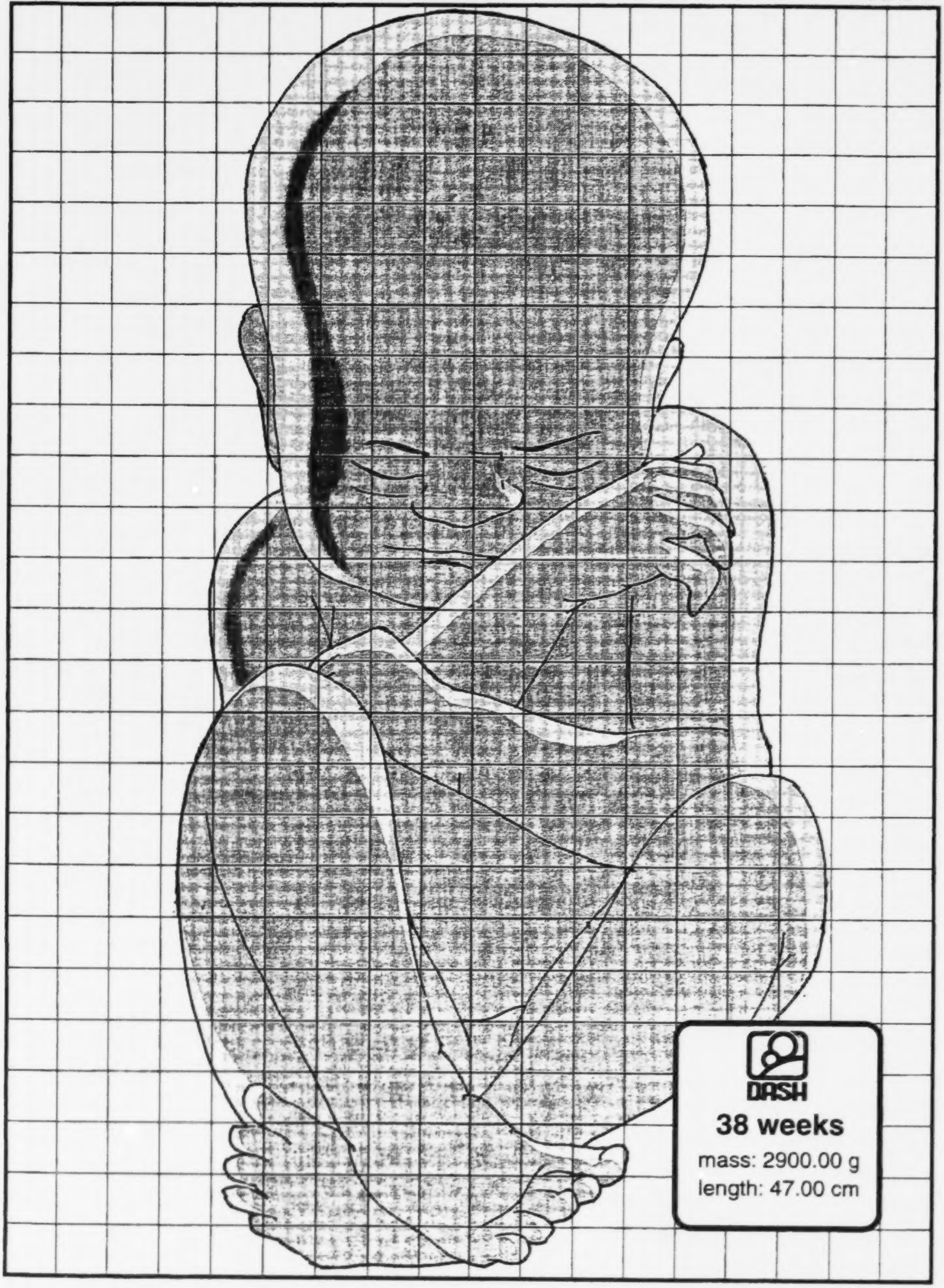
DASH

32 weeks

*mass: 1600.00 g
length: 40.00 cm
* does not include placenta

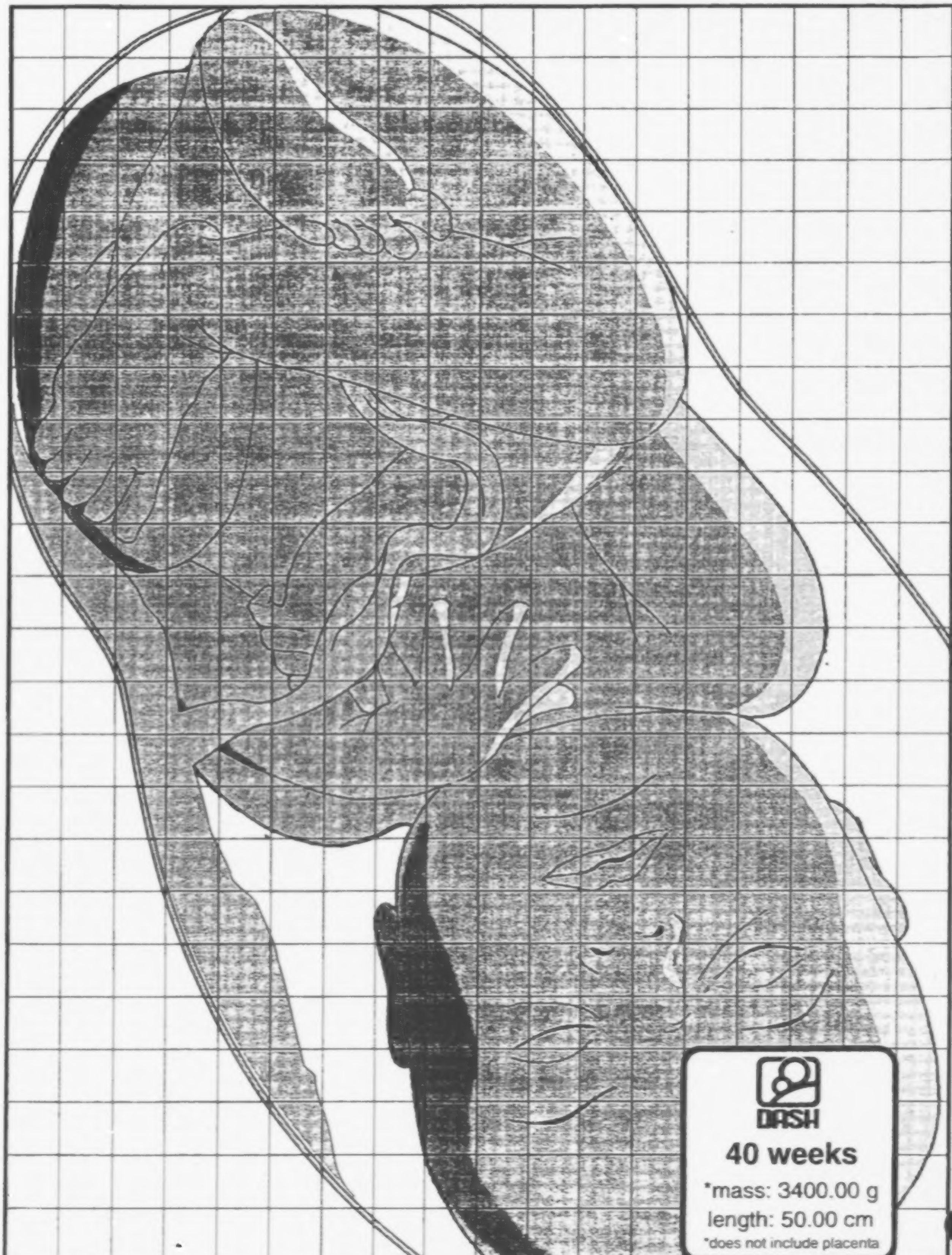

DASH
34 weeks
mass: 1900.00 g
length: 43.00 cm


DASH
36 weeks
mass: 2500.00 g
length: 45.00 cm



38 weeks

mass: 2900.00 g
length: 47.00 cm



40 weeks

*mass: 3400.00 g

length: 50.00 cm

*does not include placenta

Development Chart
Showing Approximate Mass and Length—Egg to Delivery

Week	Day	Stage	Comments	Mass (g)	Length (cm)
1	1		*Mass Very Small*	0.000005	0.01
	2	**Embryo**		0.000005	0.01
	3			0.000005	0.01
	4			0.000005	0.01
	5			0.000005	0.01
	6			0.000005	0.01
	7			0.000005	0.01
2	8			0.00004	0.02
	9			0.0003	0.07
	10			0.0009	0.12
	11			0.002	0.17
	12			0.004	0.22
	13			0.008	0.27
	14		*Mass Small*	0.01	0.32
3	21			0.15	0.71
4	28			0.30	1.00
5	35			0.90	1.40
6	42			1.20	1.90
7	49			1.60	2.30
8	56	**Fetus**		2.00	3.50
10	70			5.00	5.00
12	84			16.00	7.50
14	98			80.00	12.00
16	112			140.00	16.00
18	126			230.00	20.00
20	140			340.00	24.00
22	154			450.00	28.00
24	168			580.00	32.00
26	182			720.00	34.00
28	196			910.00	36.00
30	210			1,100.00	38.00
32	224			1,600.00	40.00
34	238			1,900.00	43.00
36	252			2,500.00	45.00
38	266			2,900.00	47.00
40	280	**Delivery**		3,400.00	50.00

Source: Based on data from *The American Medical Association Encyclopedia of Medicine,* Dorling Kindersley Limited and the American Medical Association (New York: Random House, Inc., 1989).

BEST COPY AVAILABLE

DASH

Name________________________

Date_________________________

STUDENT PAGE 5.3.10 EMBRYOLOGY

1. On a separate sheet of paper make a table to collect data on the age of the developing embryo or fetus and its length, mass, and volume. Leave space to record special developing structures. One gram of body mass is equal to 1 cubic centimeter or 1 milliliter.

2. Graph the relationship between the age and mass of the developing embryo or fetus from the 8th week.

Name ______________________________

3. Interpret the data. Describe what happens to the mass of the embryo and the fetus over the period of the pregnancy.

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4. Graph the relationship between the age and length of the fetus from the 8th week.

Name ____________________

5. Interpret the data. Describe what happens to the length of the embryo and the fetus over the period of the pregnancy.

6. Graph the relationship between the age and volume of the fetus from the 8th week. The *specific gravity* of the fetus is 1. One cubic centimeter of body tissue has the same mass as 1 cubic centimeter (1 milliliter) of water.

Name ________________________________

7. **Interpret the data. Describe what happens to the volume of the embryo and the fetus over the period of the pregnancy.**

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ACTIVITY 5.3.11 BODY CHANGES

OBJECTIVES

The students
- Predict how they will change physically between now and the beginning of the sixth grade.

BACKGROUND

The activity is designed to be done near the end of the school year. In it the students predict how they think they will change physically over the next year. This theme will be picked up in sixth grade. It is important that the students look around them and see how others a little older are changing so that they can anticipate how they will change.

STUDENT ROLES

Anatomist
Physiologist

MATERIALS

growth chart from Activity 5.6.1 GROWTH CHART
Student Page 5.3.11 BODY CHANGES

PRODUCTS

Completed Student Pages

PROCEDURES

1. **Have the students make a concept map of the term body changes.**

   Help the include such things as
   - Development.
   - Height.
   - Weight.
   - Teeth.
   - Volume.
   - Features.

2. **Have the students predict how they will change physically between now and the beginning of the sixth grade.**

EXTENSION

- Have the students use an almanac or other resources to see what the average change in dimensions is expected to be.

Name____________________________

Date____________________________

DASH

STUDENT PAGE 5.3.11 BODY CHANGES

Predict how you will change between now and the sixth grade in regard to the following:

HEIGHT ____________________________

WEIGHT ____________________________

OTHER CHANGES:

ACTIVITY 5.3.12 BONES

OBJECTIVES

The students
- Identify and count the bones they can feel in various bone groups of their bodies.
- Determine the kinds of movement of the various bone groups.
- Determine the degrees of movement of the various bone groups.
- Consider what bones can tell us about the past.

BACKGROUND

This is the first of a series of activities about the bones and muscles of the body. If possible, it should precede work on simple machines (Activities 5.8.1–5.8.9). The series is designed to give students a sense of the flexibility, power, and strength of the bone-muscle system of our bodies.

Bone Inventory

In BONES the students make an inventory of bones they can feel in their own bodies. This activity leads to Activity 5.3.13 SKELETAL SYSTEM. Usually the only bones the students cannot count by feeling are the vertebrae of the upper spine and the bones in the wrist, foot, and head. The total number of bones in the normal body is usually reported as being around 208. There is debate about whether several bones are separate or fused.

Inventing a Protractor

The students make and use a protractor to measure the amount of flexibility of selected bone-muscle groups. Help them invent a way to mark the degrees on a large circular protractor to measure the angular movements of large objects. See Figures 5.3.12(1–2).

Determining Flexibility

Using their protractors the students will find that people normally can perform the same movements with each bone-muscle group; however, the degree of flexibility or movement will differ widely. In the interest of time the study of flexibility can be divided among teams of students.

STUDENT ROLES

Anatomist
Physiologist
Archeologist

MATERIALS

string
pencils
scissors
cardboard
Student Page 5.3.12 BONES

PRODUCTS

Large protractors
Completed Student Pages

PROCEDURES

1. **Help the students make a concept map of the term bones.**

   Help them include such things as these:
   - Hard materials in our body.
   - Make up the skeleton.
   - Breakable and mendable.
   - Eaten by dogs and other flesh-eating animals. (This is the lead-in to Activity 5.3.16 CHEMISTRY AND BONES.)
   - Do not decompose very rapidly in the ground.

2. **Ask the students to estimate the total number of bones they have in their body. (There are around 208.) Then ask them how many separate bones they think they can feel well enough to count.**

3. **Have the students use Student Page 5.3.12 BONES to record the number of bones they find and draw their shapes.**

   Have the students
   - Work in pairs to validate counts.
   - Identify bones they cannot reach to count. (The vertebrae of the spine.)
   - Identify which bones are too deeply covered with tissue to count. (The vertebrae of the neck, and the skull, wrist, and ankle.)

4. **Help the students invent a large circular protractor to measure the degree of movement of various bone groups. See Figures 5.3.12(1–2).**

   Help them
   - Cut out cardboard circles.
   - Grapple with the problem of dividing the circle into 360° at 10° or 20° intervals. (See Figure 5.3.12[2].)

5. **Have the students record the kind and amount of movement of the bones listed in Student Page 5.3.12 BONES.**

   Have them
   - Measure the approximate amount of movement in degrees.
   - Record the kind of movement—up and down, back and forth, full or partially circular.

6. **Summarize the activity with the students.**

   Ask such questions as these:
   - How many bones were you able to count? (Record the various counts. They will usually run between 130 and 150.)
   - Why might our counts vary? (Some bones are more difficult to feel than others.)
   - How does the skull move on the neck? (Work for agreement that it can move in a circle of about 180° and up and down through almost 180°.)
   - How does the spine move? (Work for agreement that it moves right and left starting at the pelvis 100° to 140° or more and up and down about 80°.)
   - How does the rib cage move? (Work for agreement that it moves up and down not more than 10° to 20°.)

- How does the shoulder (the clavicle and scapulae) move? (Work for agreement that the shoulder moves up and down through 45° to 60° and back and forth through 30° to 45°.)
- How does the arm move? (Work for agreement that the whole arm moves at the shoulder next to the body through a 360° circle and up and down through 180° out to the side. At the elbow the forearm moves 180° up and down. The forearm twists through 180°.)
- How does the leg move? (Work for agreement that the entire leg moves in a kicking motion from 160° to 220°, depending on flexibility, and out and back toward the body from 90° to 120°. At the knee the lower leg moves about 180°. The lower leg can twist between 90° and 140°.)
- How does the pelvis move? (Work for agreement that because it is a single bone, it does not move and is the center around which the rest of the body moves.)
- How does the foot move? (Work for agreement that the toes can curl about 90°, that the entire foot can twist over 90° right to left, and that the foot can move up and down from 60° to 80°.)
- How do the hand and wrist move? (Work for agreement that they move at the wrist up and down about 180° and right and left from about 45°. The hand can twist under itself about 90°, and the fingers and thumb can curl about 270°.)
- What is the only part of the outside of your body that you cannot reach? (The middle of the back behind the rib cage.)

7. **Have the students think of ways archeologists might use fossilized bones to investigate the evolution of animals.**

Ask such questions as these:

- How similar do the bones in each of our bodies seem to be? (Work for agreement that they are a good deal alike, differing mainly in size and the number we can feel through our flesh. We all have the same number of major bones unless we have had an accident.)
- If you came upon a very old skeleton, could you tell whether it was a human, a turkey, a large dog, or a fish? What would the differences be that would give you clues?
- If two skeletons have the same the number of bones, but the shape and size of the bones are quite different, what must we conclude? (Have the students work on this in groups and give their ideas. One conclusion might be that the animals were related but of a different kind; for example, one might be a dog and the other a cat.)

- What might the teeth tell us? (Work for such things as the kind of food eaten—grinding teeth could indicate a diet of grasses and leaves; sharp pointed teeth, a meat diet, and so forth.)
- What do our teeth say about the diet we can handle? (We seem to be designed to be *omnivores* because we have grinding molars for eating grains and grasses and incisors for cutting and tearing meat.)

EXTENSIONS

Have the students

- Write a story about the flexibility of the human body.
- Observe the movement of gymnasts to see how flexible their bodies are.
- Observe how animals move various parts of their bodies.
- Research the differences between dinosaur bones and the bones of animals living today.
- Research the manufacture of artificial bones and bone parts for the human body.
- Research how broken bones are repaired.

ILLUSTRATIONS

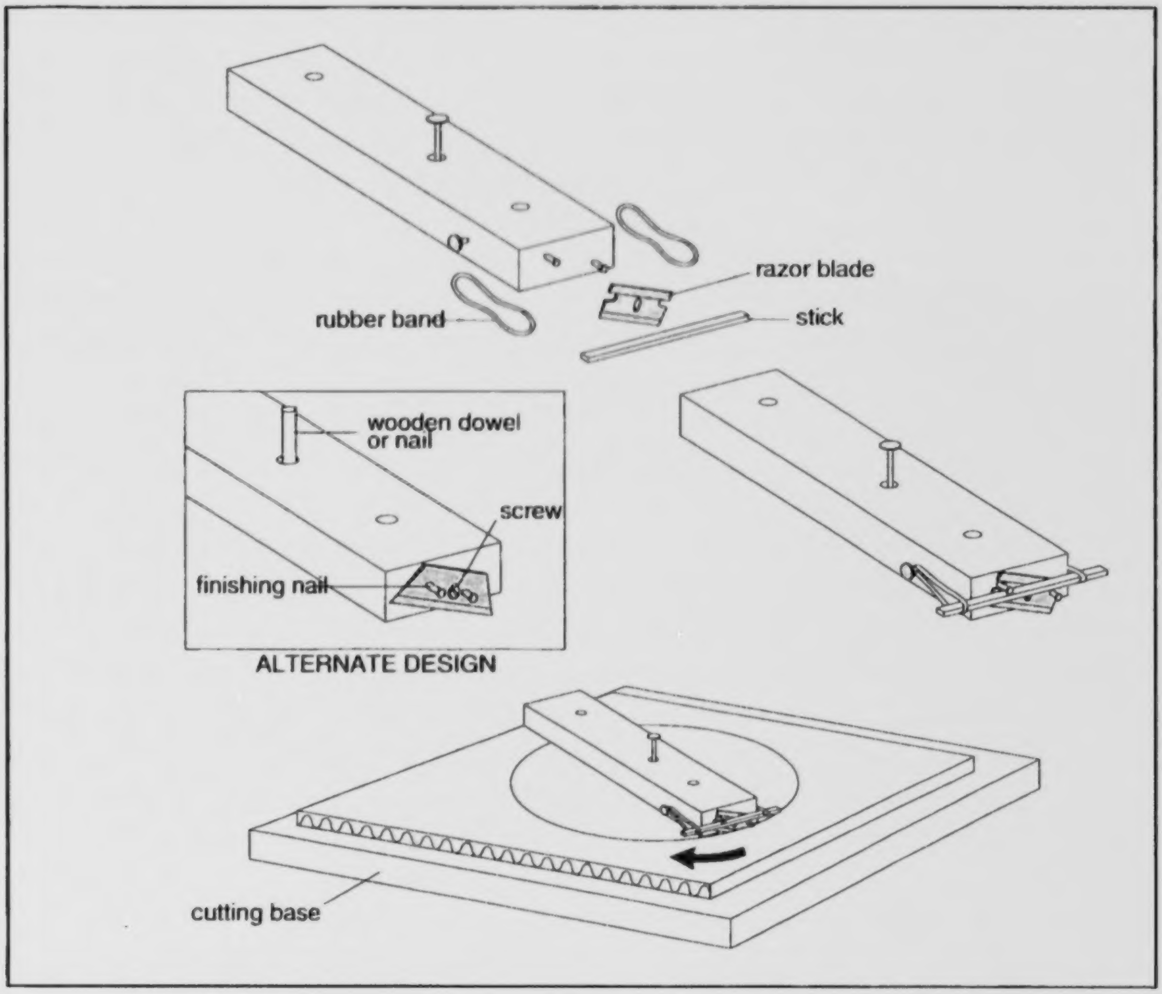
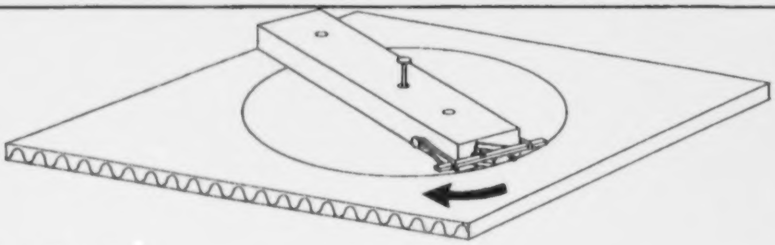
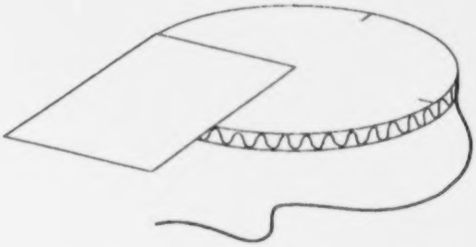

razor blade
rubber band
stick
wooden dowel or nail
screw
finishing nail
ALTERNATE DESIGN
cutting base

Figure 5.3.12(1) Design for a circle cutter



STEP 1 Cut a cardboard circle 25–30 cm in diameter.

STEP 2 Divide the circle into quarters using notebook paper.



STEP 3 Measure the perimeter of the circle with a piece of string. Divide the string into quarters.

STEP 4 Divide the quarters into 9 units of 10° each.

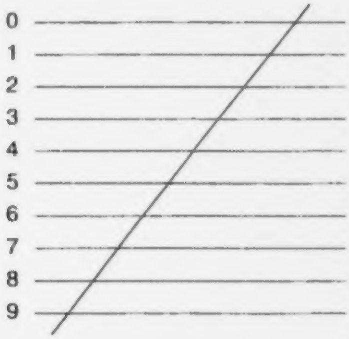


Figure 5.3.12(2) Making a 360° protractor

DASH

Name______________________

Date______________________

STUDENT PAGE 5.3.12 BONES

1. Draw the bones of the following areas as you think they would look from the way that they feel. Put the number of bones you find of this kind in the parentheses next to the name of the bone group.

Skull including the jaw — Number of bones ( )

Spine — Number of bones ( )

Subtotal ( )

Name ______________________

Ribs **Number of bones (   )**

Shoulder bones **Number of bones (   )**

Pelvis **Number of bones (   )**

Arm **Number of bones (   )**

Subtotal (   )

Name ____________________

Leg Number of bones (   )

Hand and wrist Number of bones (   )

Foot Number of bones (   )

Subtotal (   )
Grand total (   )

2. Make a 360° protractor and describe how you made it.

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____

____

____

____

Name ____________________

3. **Describe the ways the different bone-muscle groups move and record the amount of movement in degrees.**

The skull

The spine (vertebrae)

The rib cage

The shoulder

The arm

Name ____________________

The leg

The pelvis

The foot

The hand and wrist

ACTIVITY 5.3.13 SKELETAL SYSTEM

OBJECTIVES

The students
- Create diagrams reflecting the way they think the bones in their bodies look and are connected.
- Assemble three-dimensional paper models of the skeletal system.
- Compare their original diagrams with their models.
- Use their models to observe how bones work together during specific activities.

BACKGROUND

This activity should follow Activity 5.3.12 BONES and precede Activity 5.3.14 MUSCLES. In SKELETAL SYSTEM the students sketch their vision of the human skeleton. They then assemble a model of a skeleton and check it with their drawing. Finally, they use their model to observe how the bones operated under specific situations.

It will be helpful to have a real human skeleton to guide in checking the assembled paper model. If a real skeleton is not available, a small plastic model can be used. Large charts are also useful and these can usually be borrowed from a secondary school or a physician. Do not bring in the skeleton, models, or charts until after the students have had a chance to work at assembling their model.

STUDENT ROLES

Anatomist
Physician

MATERIALS

tape
scissors
human skeleton or model
Student Page 5.3.13 SKELETAL SYSTEM

PRODUCTS

Models of the human skeleton
Completed Student Pages

PROCEDURES

1. **Review the investigation of bones in Activity 5.3.12 BONES. Have the students sketch their vision of the entire human skeleton.**

   Ask such questions as
   - In your research, approximately how many bones did you find are in the human body? (By inspection they will usually have found between 120 and 150 bones and in references somewhere from 206 to 208.)
   - Which bones were difficult to count? (The ones in the head, wrist, foot, and upper spine.)
   - What do you think the complete skeleton looks like?

2. **Introduce Student Page 5.3.13 and help the students assemble the skeleton. Have them use tape to hold moving bones. See diagrams. The tape can be cut and replaced if there are errors in assembling.**

3. **Have the students hang their model for inspection, using string attached to the pelvis and strung through the spine and the skull.**

   Have them
   - Test their model to be sure that the bones have the same approximate flexibility as those in their own body. Major bones that move should be taped or folded to allow movement.
   - Compare their model with those of others in the class.

4. **Have the students compare their cut-out model with a real human skeleton, plastic model, or skeletal charts.**

5. **Have the students use their models to show how the bones operate when making common movements.**

Have them show their model
- Lifting a ball from the ground to overhead.
- Throwing a ball.
- Kicking a ball.
- Running.
- Engaging in other activities that they suggest.

6. **Compare the diagram that they made in the first of the activity with their assembled skeleton.**

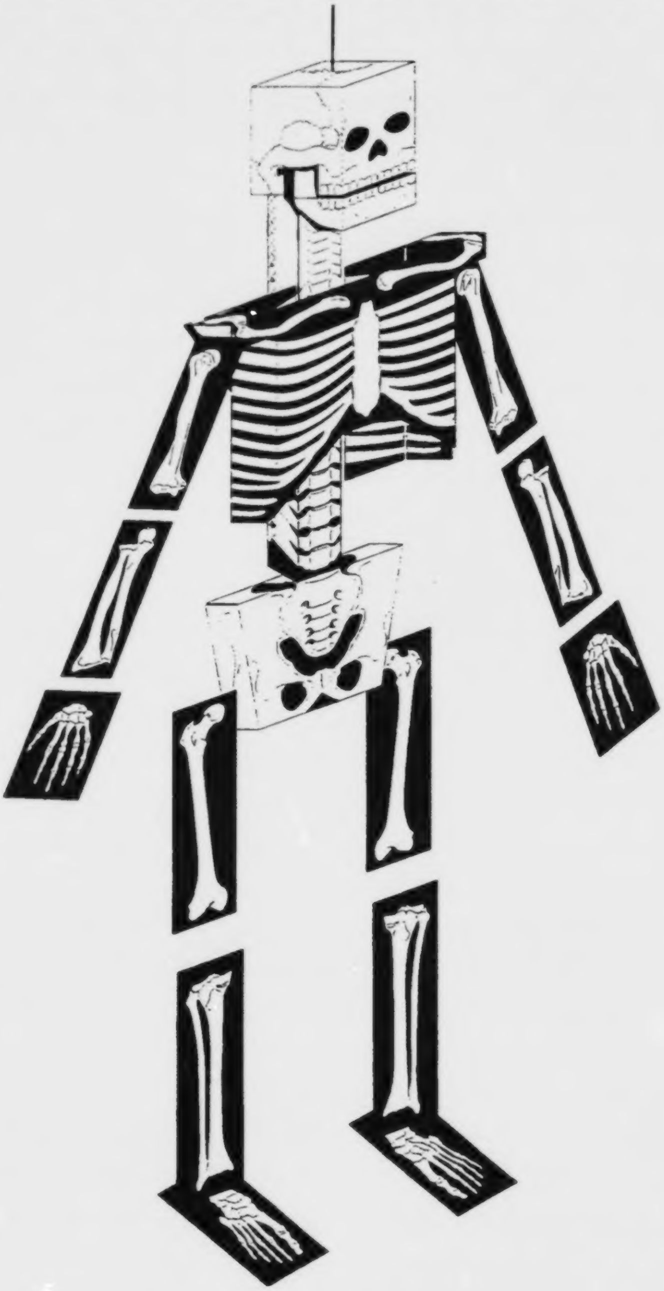
Ask such questions as
- How close was your drawing to the model?
- How well were you able to get a sense of the shape of bones by feeling them?
- Why do we have so many bones? (Get at ideas of flexibility and specific kinds of movement.)

EXTENSIONS

Have the students
- Make a bulletin board display of skeletons.
- Write verses to the song *Dry Bones* to help them remember the bones of their bodies and their attachments.
- Bring in skeletons of small animals that they find and try to assemble them using glue. Have them compare these skeletons with their human skeleton.
- Steam-cook a fish and tease away the muscles from the bones. Glue the bones to cardboard. Have them compare the skeleton with a human skeleton.

DASH	SP 5.3.13 SKELETAL SYSTEM	Name ____________ Date ____________

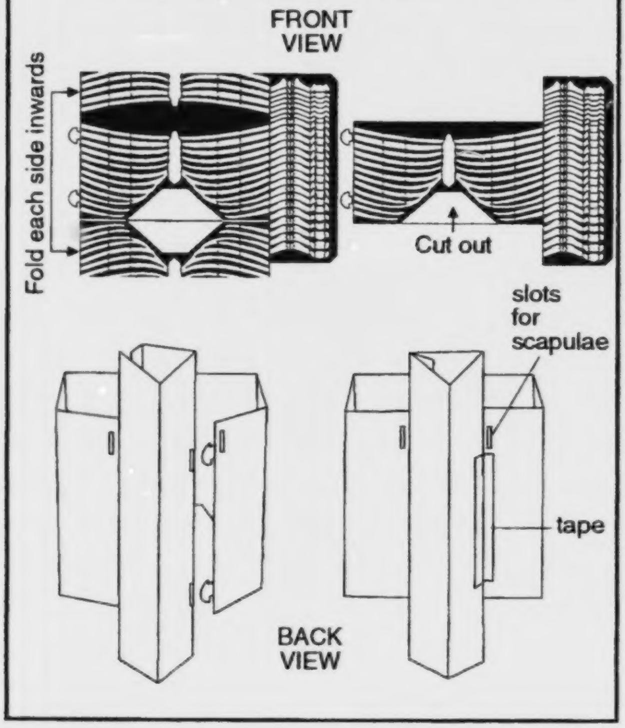
Cut out the pieces of the skeleton and assemble them using tape and string.



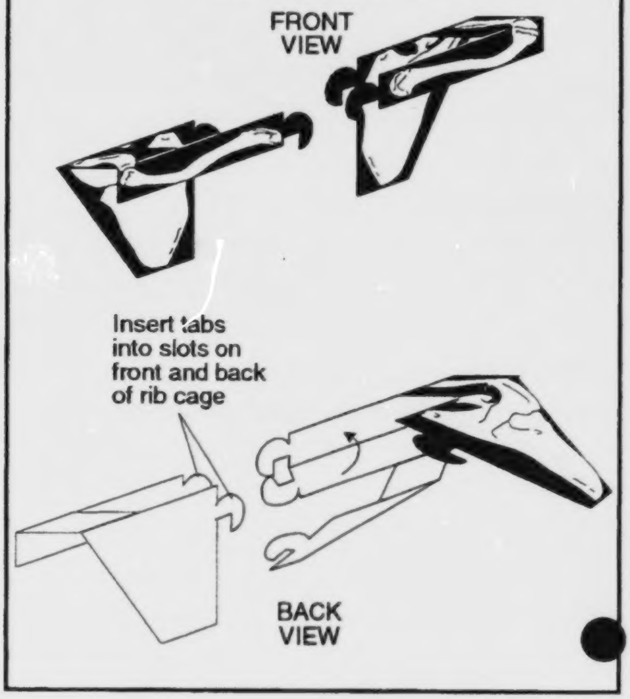
Assembled model of human skeleton

INSTRUCTIONS FOR ASSEMBLY OF SKELETON

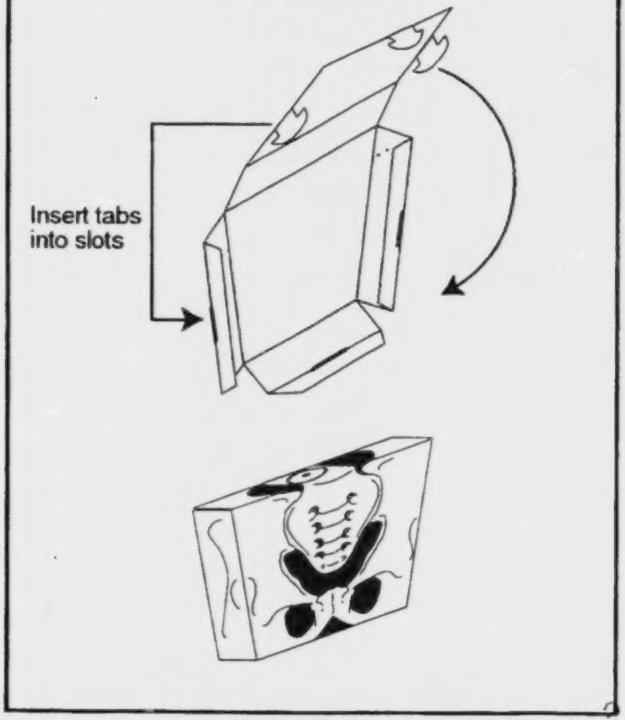
FOLDING SPINE AND CHEST


FRONT VIEW
Fold each side inwards
Cut out
slots for scapulae
tape
BACK VIEW

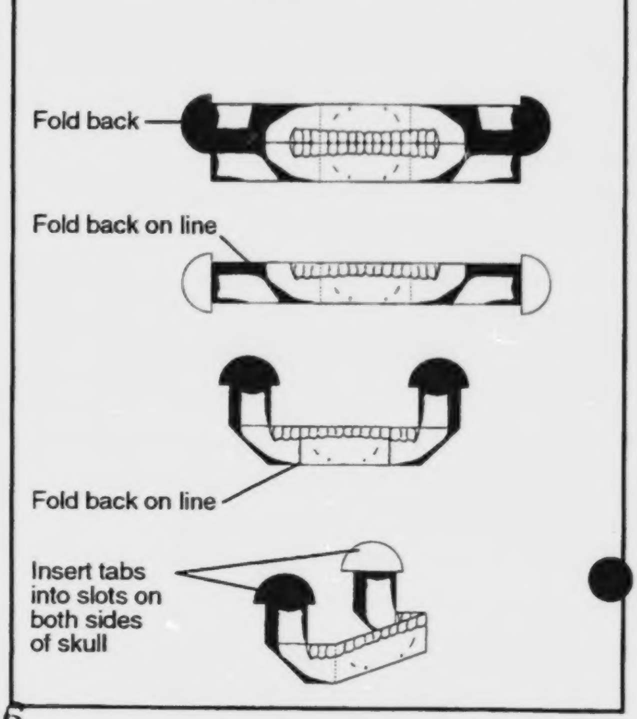
FOLDED CLAVICLES AND SCAPULAE


FRONT VIEW
Insert tabs into slots on front and back of rib cage
BACK VIEW

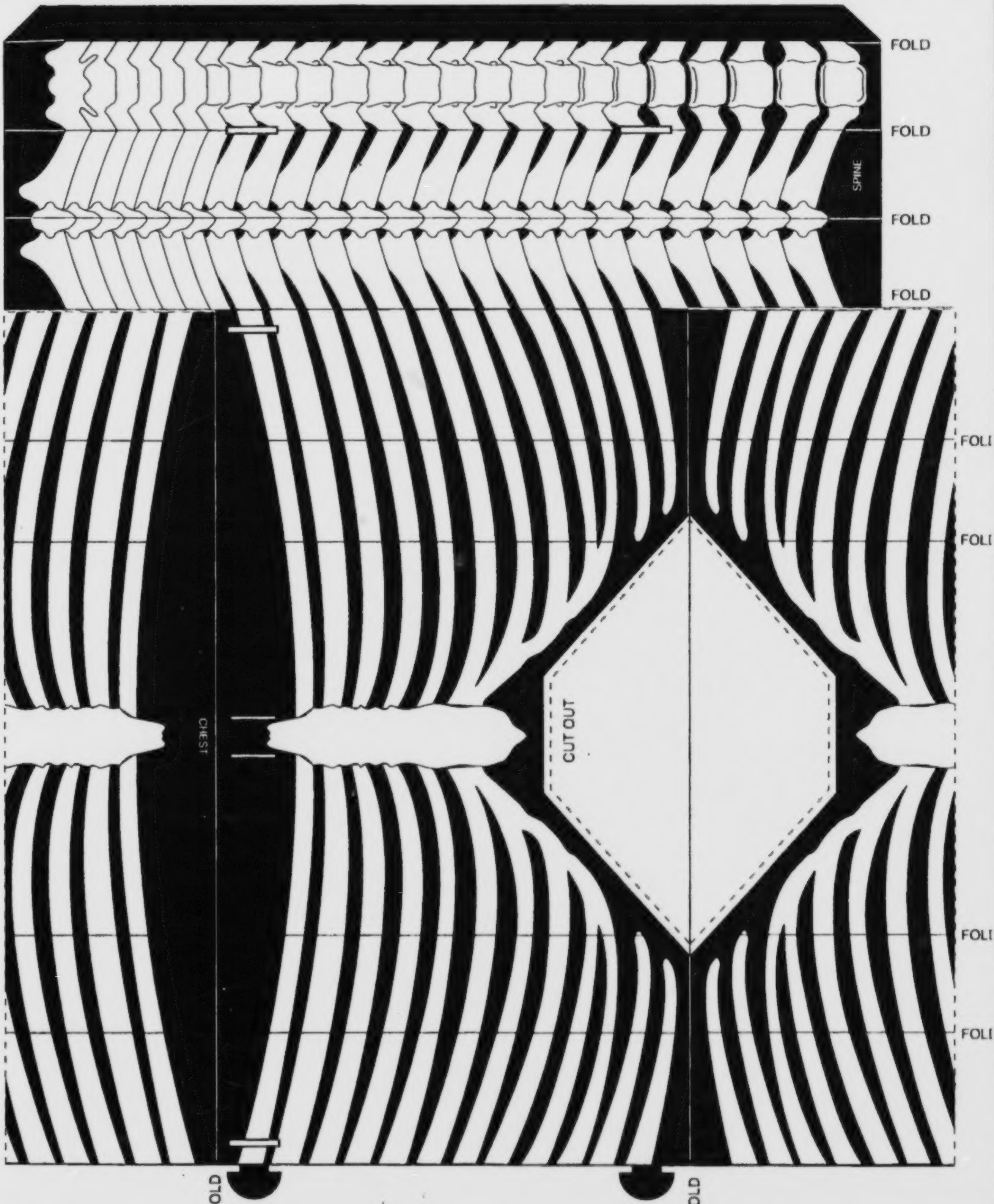
FOLDED PELVIS


Insert tabs into slots

FOLDING JAW

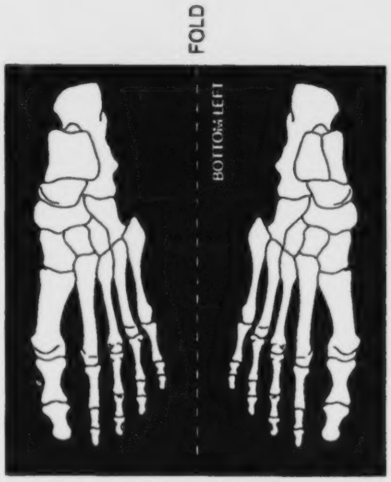

Fold back
Fold back on line
Fold back on line
Insert tabs into slots on both sides of skull

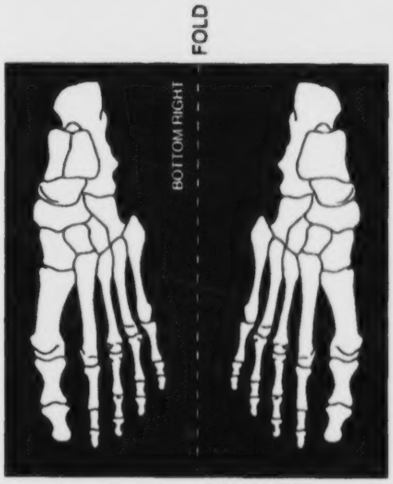
SPINE AND CHEST


FOLD
FOLD
SPINE
FOLD
FOLD
FOLI
FOLI
CHEST
CUT OUT
FOLI
FOLI
FOLD
FOLD

BEST COPY AVAILABLE

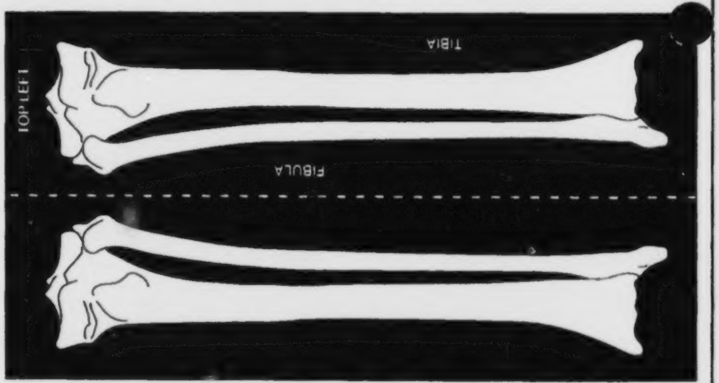
FEET

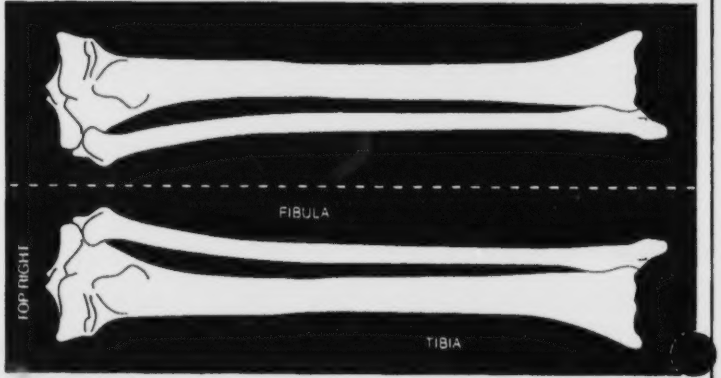

FOLD
BOTTOM LEFT


FOLD
BOTTOM RIGHT

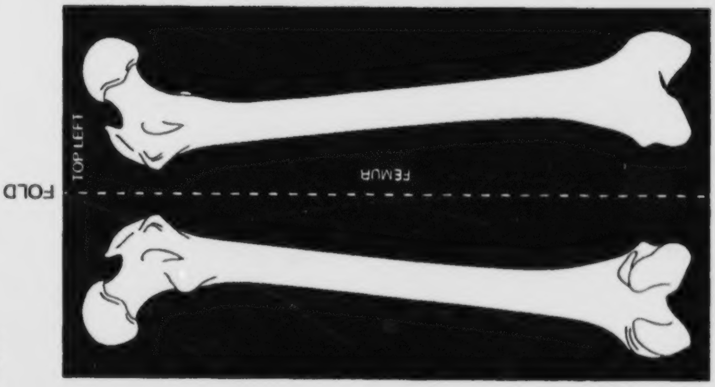
LEGS

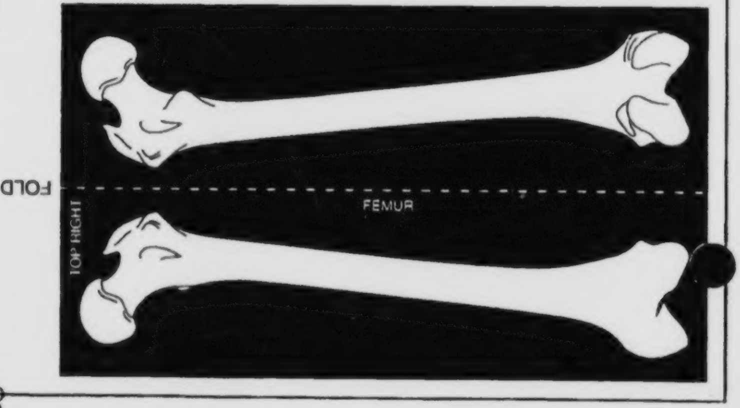
TIBIA AND FIBULA


TIBIA
TOP LEFT
FIBULA
FOLD

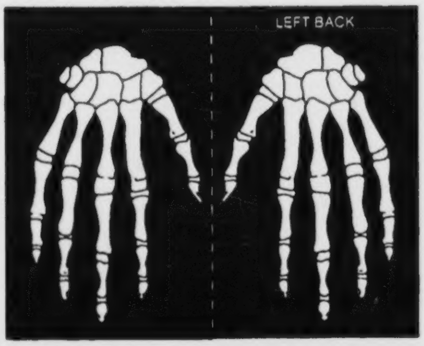

FOLD
FIBULA
TOP RIGHT
TIBIA

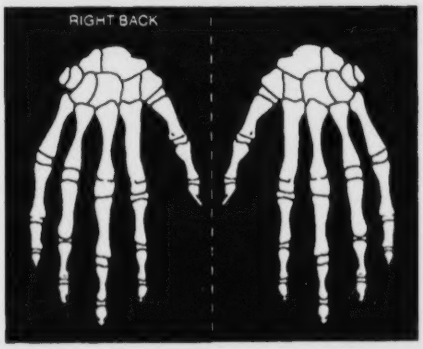
FEMUR


TOP LEFT
FOLD
FEMUR


FOLD
FEMUR
TOP RIGHT

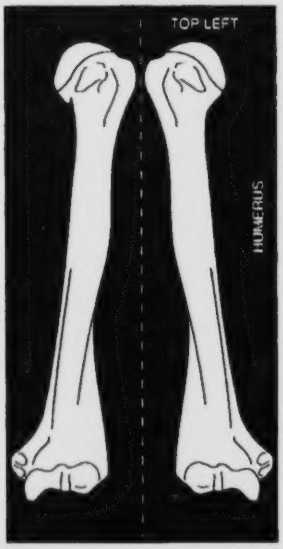
HANDS

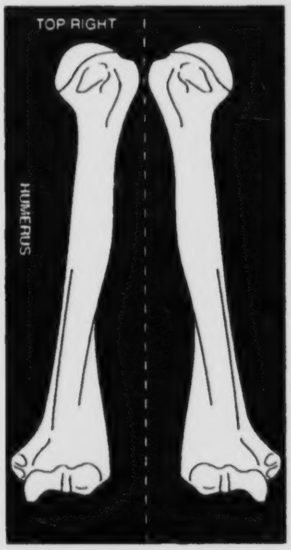

FOLD
LEFT BACK


FOLD
RIGHT BACK

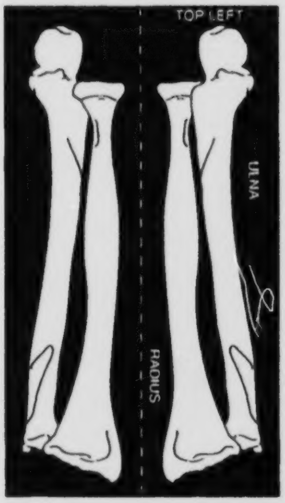
ARMS

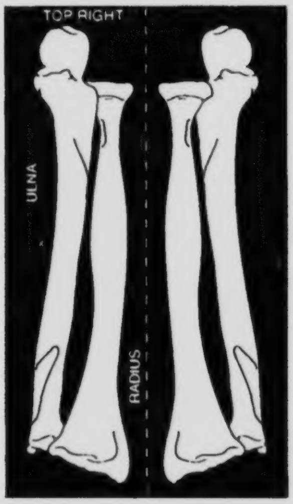
HUMERUS


FOLD
TOP LEFT
HUMERUS

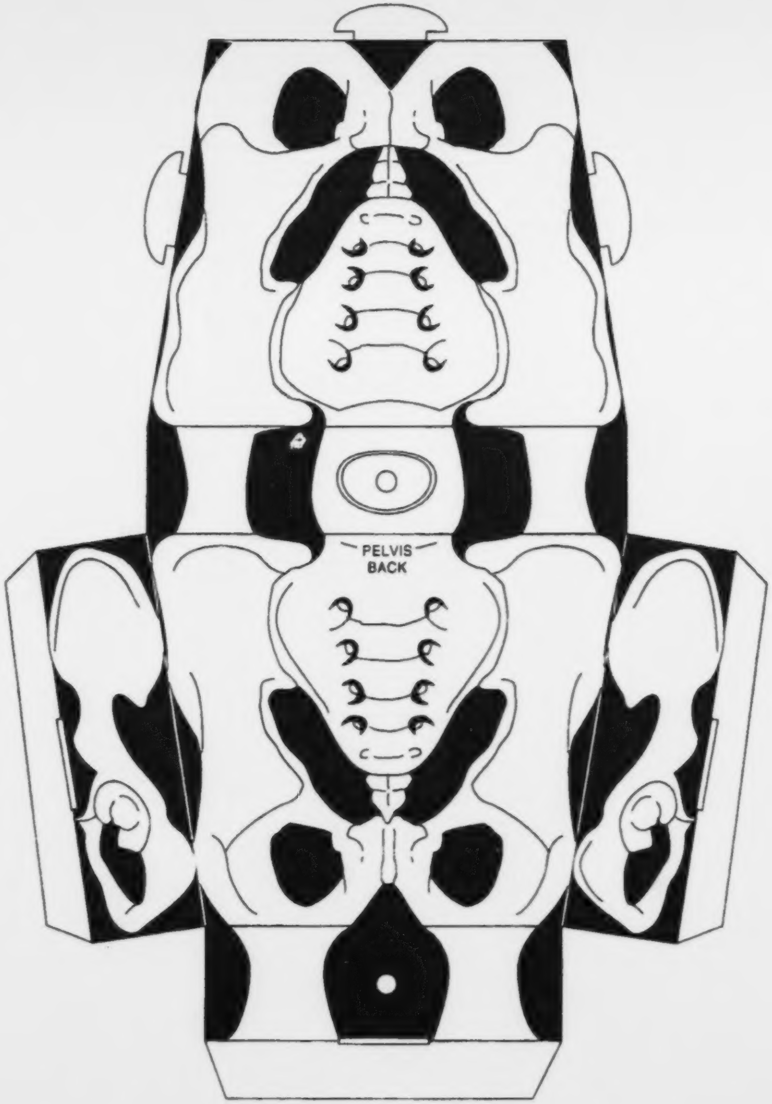

FOLD
TOP RIGHT
HUMERUS

RADIUS AND ULNA

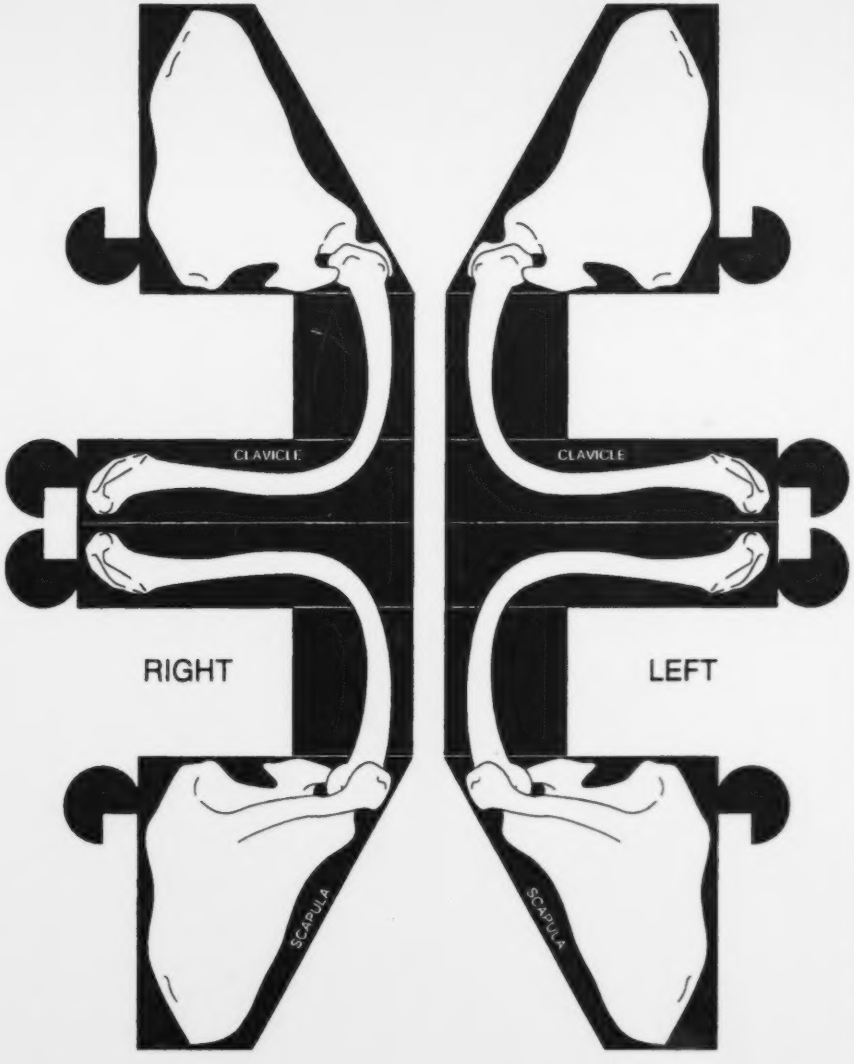

FOLD
TOP LEFT
ULNA
RADIUS


FOLD
TOP RIGHT
ULNA
RADIUS

PELVIS

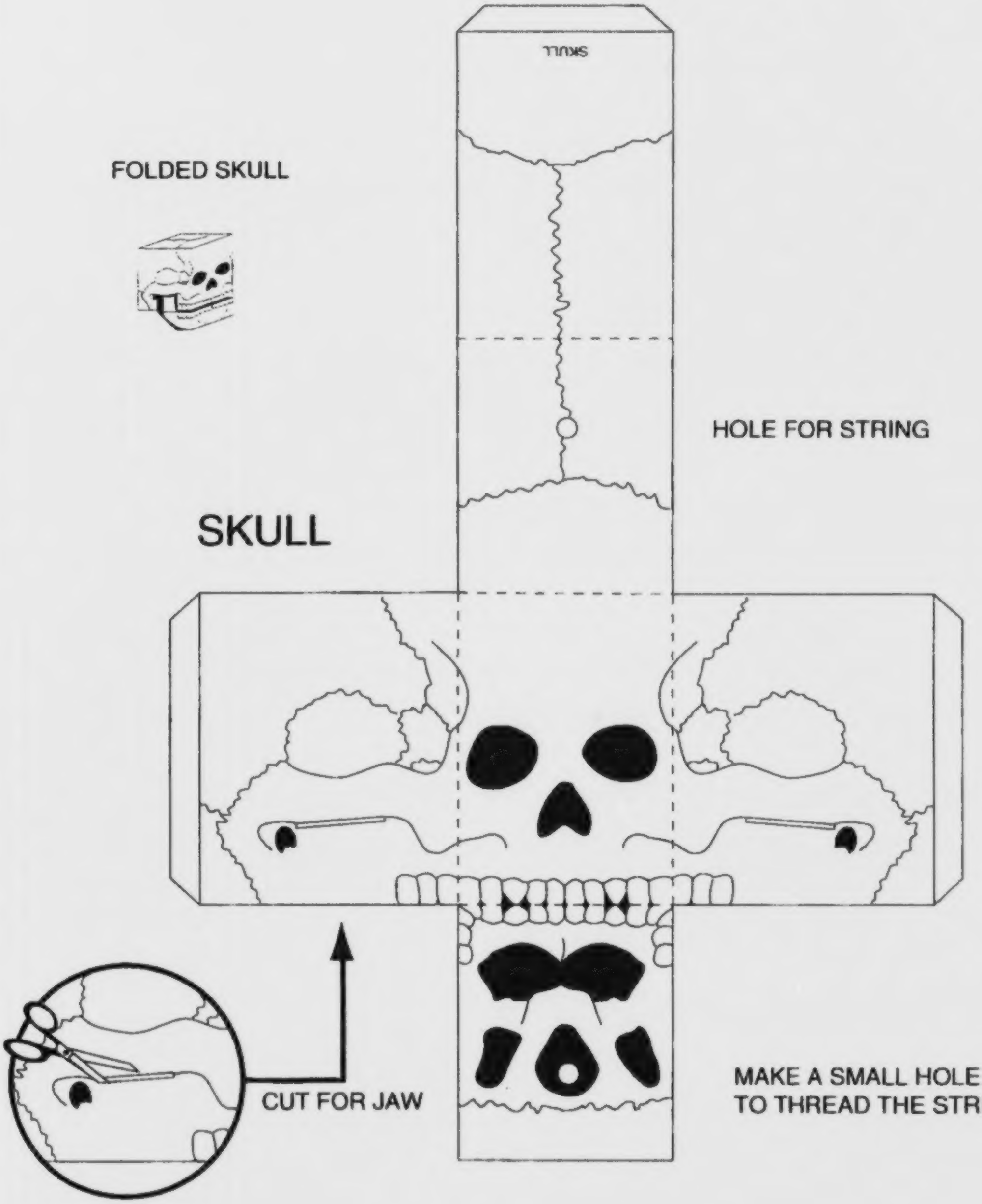

PELVIS BACK

CLAVICLES AND SCAPULAE

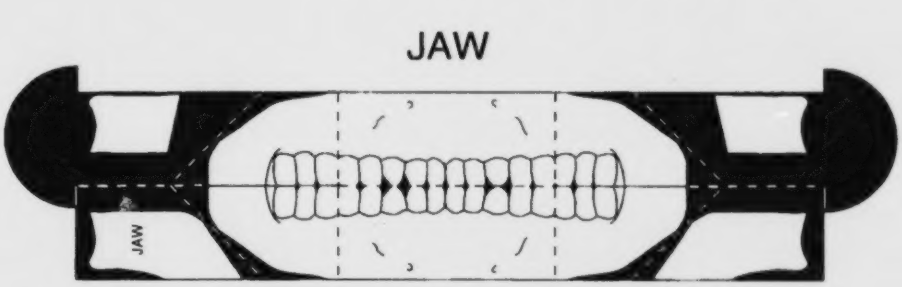

CLAVICLE
CLAVICLE
RIGHT
LEFT
SCAPULA
SCAPULA

FOLDED SKULL

SKULL


SKULL
HOLE FOR STRING
CUT FOR JAW
CUT FOR JAW
MAKE A SMALL HOLE
TO THREAD THE STRING

JAW



ACTIVITY 5.3.14 MUSCLES

OBJECTIVES

The students

- Make a concept map of the term muscle.
- Locate muscles that move selected bones.
- Find muscle origins and insertions.
- Identify muscles as flexing or extending.
- Draw stick diagrams of muscle-and-bone groups.

BACKGROUND

This activity introduces muscles in the same way that bones were introduced—by feeling them. It should follow Activity 5.3.13 SKELETAL SYSTEM and precede Activity 5.3.15 MUSCULAR SYSTEM.

Approach

Have the students try to find where muscles are attached to bones. The anatomist calls the attachment to the bone that moves the least the *origin* and the attachment to the bone that moves the most, the *insertion*. To find the muscle that does the moving, create a resistance to the movement. A book laid on the palm of the hand resists pulling the forearm up. A palm pushing down on a table resists returning the forearm to a straight position. In each case the muscle under the greatest tension or *contraction* feels the hardest and is the muscle primarily responsible for the movement. Having located the muscle, the students can feel the approximate location of the *insertion* on the moving bone. By going to the opposite end of the muscle they can find the approximate location of the *origin*. See Figure 5.3.14(1).

Stick diagrams for suggested explorations are shown in Figure 5.3.14(2). The diagrams also provide background for later study of how bones act as levers. See Activities 5.8.5 LEVERS: WHERE ARE THEY? and 5.8.6 ARMS AND JAWS.

Mnemonic

The following mnemonic may help the students recall how the muscles and bones are connected and operate.

MOBILE MNEMONIC

Muscles move our bodies' bones. A muscle is secured or held fast at its
Origin to move a
Bone connected at the other end at a spot called the
Insertion. When the muscle shortens or contracts by bulging, it can
Lift the bone. When the muscle
Elongates or relaxes, the bone returns to its starting position.

Tendons

The students will find that the muscles appear at first glance to become smaller and ropy at the point where they connect to bones, for example, where the biceps connects to the radius. The rope-like structures are *tendons,* tough tissues that bind muscles to bones.

Models

Models can be made from sticks, tape, and rubber bands. It is helpful to have groups of students make models of various bone-muscle combinations and share them with the class.

Vocabulary

Muscles have paired operations: One muscle or set of muscles *flexes* or moves a bone from its normal relaxed position; another muscle or muscle set *extends* or brings it back where it was originally. We say that these two muscles or sets of muscles are *antagonistic* to each other.

STUDENT ROLES

Anatomist
Exercise physiologist

MATERIALS

rubber bands
string
tape
sticks
skeleton model from Activity 5.3.13 SKELETAL SYSTEM
Student Pages 5.3.14 MUSCLES

PRODUCTS

Models and diagrams of bone-muscle systems
Completed Student Pages

PROCEDURES

1. **Make a concept map of the term muscle with the students.**

   Be sure to include such things as these:
   - Flesh.
   - Attached to bone.
   - Move our body.
   - Strength.
   - Biceps, triceps, gluteus maximus, and so forth.

2. **Instruct the students how to find muscles. Have them begin with the *biceps,* the muscle that draws the forearm upward. Have them keep their skeleton model on hand.**

   Have the students
   - Hold a book in their hand.
   - Lift the book to their shoulder.
   - Feel their arm to find the muscle that does the lifting. (This muscle is the *biceps.*)
   - Describe what happens to the muscle as it pulls up the book. (Work to the idea that the muscle seems to swell and get harder.)
   - Find where the muscle seems to be attached to the moving bones of the forearm, the muscle's *insertion.* (If they are careful, the students can feel that it is attached to the bone that is on top when the hand is held so that the thumb is up. This bone is the *radius.* See Figure 5.3.14[1].)
   - Find the origin of the biceps. (Though they will not be able to feel the origin, they will normally conclude that the muscle is attached to the bones of the shoulder. The biceps has two attachments, giving it its prefix "bi-," which means two. One origin is on the clavicle, the other on the scapula.)
   - Describe what the muscle feels like at the point of attachment to the radius. (Work to the idea that it feels like a cord or rope. Introduce the term *tendon* to describe the tissue that binds muscles to bones.)
   - Suggest an explanation of how the muscle moves the forearm. (Work toward the observations that the muscle when it contracts

seems to pull on the tendon and that it shortens while pulling the radius. Have one or more students make a model of sticks and rubber bands to show this.)

3. **Have the students use their model skeleton to help them draw the humerus, radius, ulna, and the biceps muscle. Help them label the bones, muscle, and insertion on the radius and the origin in the general area of the shoulder. Have them use Student Page 5.3.14 MUSCLES.**

4. **Help the students find the muscle that extends the arm and restores it to its straightened position. Have them bend their arm and push down on a table with their fist. The muscle that is under the most tension is the triceps. See Figure 5.3.14(1).**

   Help them
   - Find the muscle.
   - Find where the origin seems to be. (Again, the origin will appear to be on the shoulder bones, actually on a scapula.)
   - Find where the insertion on a moving bone seems to be. (It will attach right at the end of the ulna.)
   - Make a diagram of the humerus, radius, ulna, and the triceps muscle. Show how the triceps is connected to the ulna. Label the bones, the triceps and *origin* in the shoulder area and the *insertion* on the ulna. Use the student page.

5. **Help the students explore the way other muscles operate. Have them use stick diagrams to show the muscles and bones that seem to be involved in movements. See Figure 5.3.14(2).**

   Help them include the following:
   - Lifting the upper leg.
   - Pulling the upper leg down.
   - Pulling the front of the foot down to walk on the toes.
   - Raising the front of the foot to walk on the heel.
   - Exploring with other muscles and bones.

EXTENSION

- Have the students make stick-and-rubber band models of other bone-muscle systems.

ILLUSTRATIONS

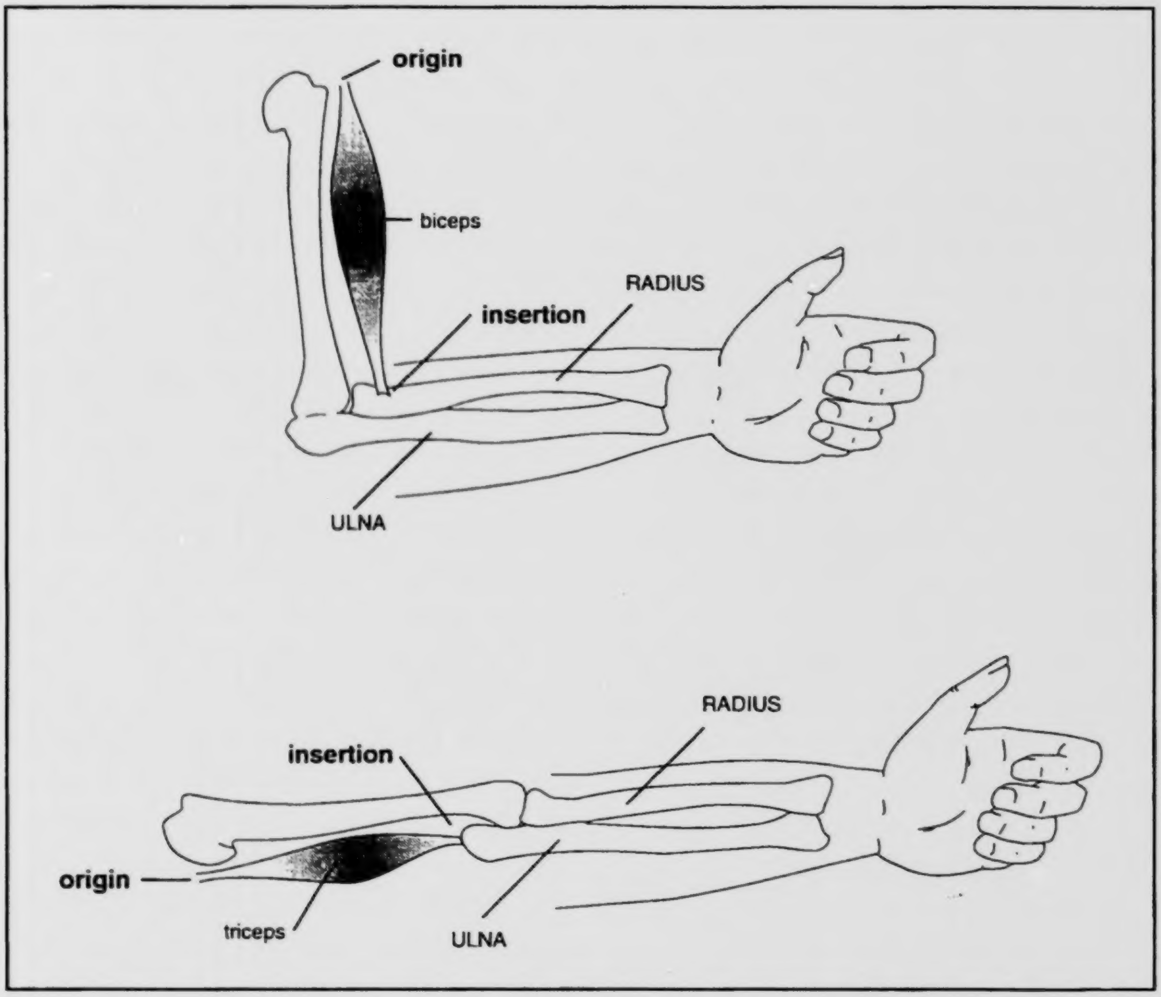

origin
biceps
RADIUS
insertion
ULNA
RADIUS
insertion
origin
triceps
ULNA

Figure 5.3.14(1) Insertion and origin of the biceps and triceps

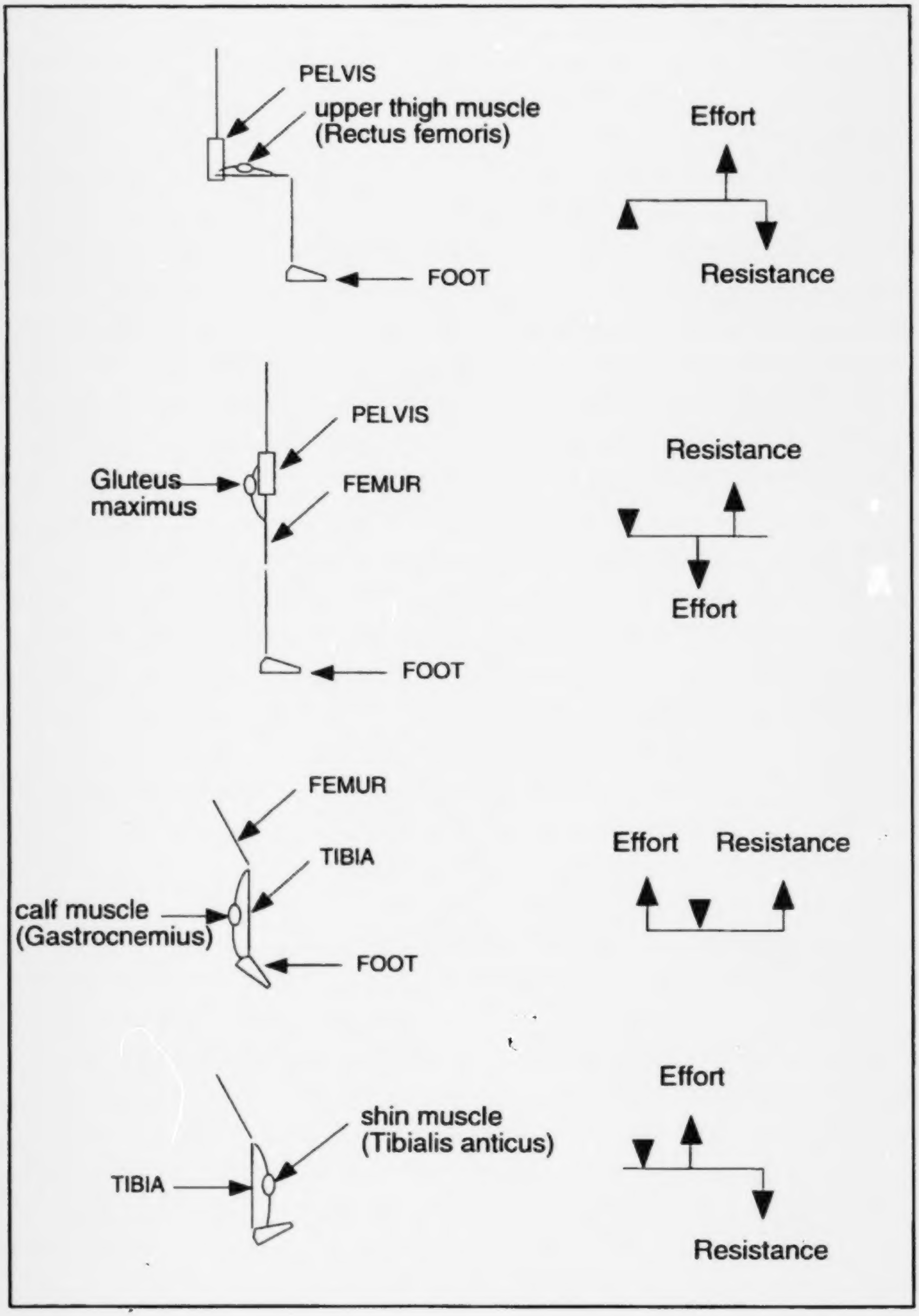

PELVIS
upper thigh muscle
(Rectus femoris)
FOOT
Effort
Resistance
PELVIS
Gluteus maximus
FEMUR
FOOT
Resistance
Effort
FEMUR
TIBIA
calf muscle
(Gastrocnemius)
FOOT
Effort
Resistance
shin muscle
(Tibialis anticus)
TIBIA
Effort
Resistance

Figure 5.3.14(2) Muscle-and-bone systems

DASH

Name________________________

Date________________________

STUDENT PAGE 5.3.14 MUSCLES

1. Make a diagram of the humerus, radius, ulna, and the muscle that flexes the forearm. Show the insertion and the general area of the origin of the muscle. Label the bones, the muscle, and the muscle's insertion and origin.

2. Refer to the mnenomic below as you carry out the activities.

MOBILE MNEMONIC

Muscles move our body's bones. A muscle is secured or held fast at its
Origin to move a
Bone connected at the other end at a spot called the
Insertion. When the muscle shortens or contracts by bulging, it can
Lift the bone. When the muscle
Elongates or relaxes, the bone returns to its starting position.

Make a diagram of the humerus, radius, ulna, and the muscle that extends or straightens the forearm. Show the insertion and the general area of the origin of the muscle.

Name________________________________

insertion and the general area of the origin of the muscle. Label the bones, the muscle, and the muscle's insertion and origin.

3. **Make stick diagrams showing the pelvis, upper and lower leg, and foot in the movements listed. Show the muscle or muscles producing each movement. Label the origin and insertion. Include the following movements and any others you may have explored.**

   - **Lifting the upper leg up.**

   - **Pulling the upper leg down.**

Name______________________________

- **Pulling the front of the foot down to walk on the toes.**

- **Raising the front of the foot up to walk on the heel.**

ACTIVITY 5.3.15 MUSCULAR SYSTEM

OBJECTIVES

The students
- Make a concept map of the term muscular system.
- Label a diagram with the common names of muscles.
- Determine the functions of the various muscles shown on the diagram.
- Label the muscles identified in Activity 5.3.14 MUSCLES.

BACKGROUND

This activity should follow Activity 5.3.14 MUSCLES and precede Activity 5.8.6 ARMS AND JAWS in which the students investigate bones and muscles as levers. In MUSCULAR SYSTEM the students begin by creating a concept map of term muscle system. This is a collective term for the muscles of the body. The students then use diagrams to give common names to the major muscles of the body, including the muscles they studied in Activity 5.3.14. They conclude the activity by exploring the functions of specific muscles.

STUDENT ROLES

Anatomist
Taxonomist

MATERIALS

Student Pages	5.3.14 MUSCLES 5.3.15 MUSCULAR SYSTEM

PRODUCTS

Completed Student Pages

PROCEDURES

1. **Help the students make a concept map of the term muscular system.**

Help them include such things as
- Muscles of the body.
- A system like the skeletal system
- Muscles working for a common purpose.
- Antagonistic muscles.
- Operators of the skeletal system.

2. **Have the students complete Student Page 5.3.15 MUSCLE NAMES. Help them find the muscles they located in Activity 5.3.14 MUSCLES. See Figures 5.3.15(1-2).**

   Ask such questions as these:
   - What muscle pulls the upper arm up? (The *deltoid* or shoulder muscle.)
   - What muscle pulls the upper arm down? (The *pectoralis major* or chest muscle.)
   - What muscle lifts the upper leg? (The *rectus femoris* or thigh muscle.)
   - What muscle pulls the upper leg down? (The *gluteus maximus* or rump muscle.)
   - What is the muscle that pushes the front of the foot down? (The *gastrocnemius* or calf muscle.)

EXTENSIONS

Have the students
- Make a bulletin board display of the muscular system. A medical dictionary will have detailed listing of muscles and their functions.
- Write new verses to the song *Dry Bones* to help them remember the muscles of their bodies and the bones they move.
- Make stick skeleton models or diagrams to show the operation of other muscles of the body.
- Research ways damaged muscles and tendons are repaired.

ILLUSTRATIONS

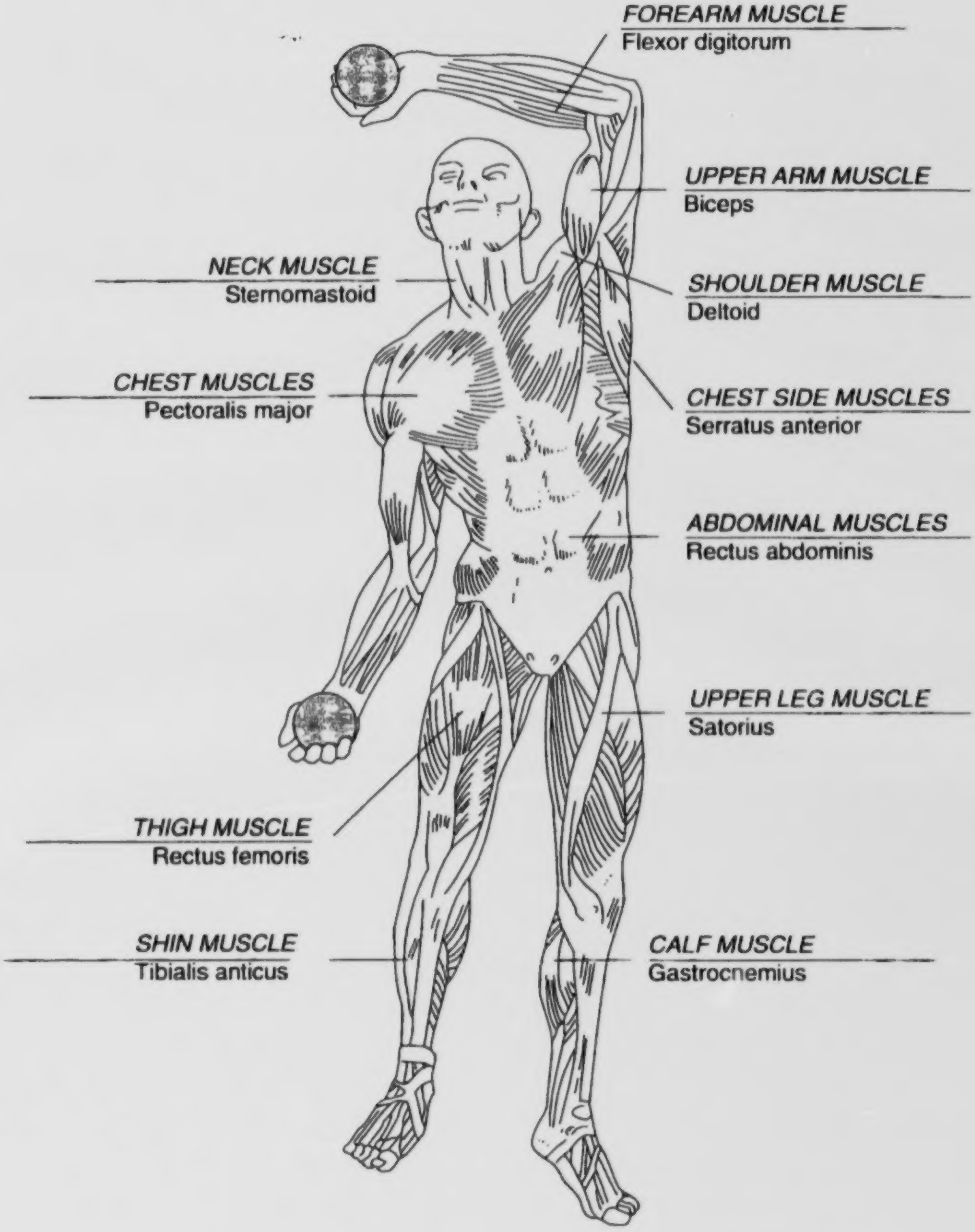

FOREARM MUSCLE
Flexor digitorum
UPPER ARM MUSCLE
Biceps
NECK MUSCLE
Sternomastoid
SHOULDER MUSCLE
Deltoid
CHEST MUSCLES
Pectoralis major
CHEST SIDE MUSCLES
Serratus anterior
ABDOMINAL MUSCLES
Rectus abdominis
UPPER LEG MUSCLE
Satorius
THIGH MUSCLE
Rectus femoris
SHIN MUSCLE
Tibialis anticus
CALF MUSCLE
Gastrocnemius

Figure 5.3.15(1) Common and scientific names of muscles of the body (front view)

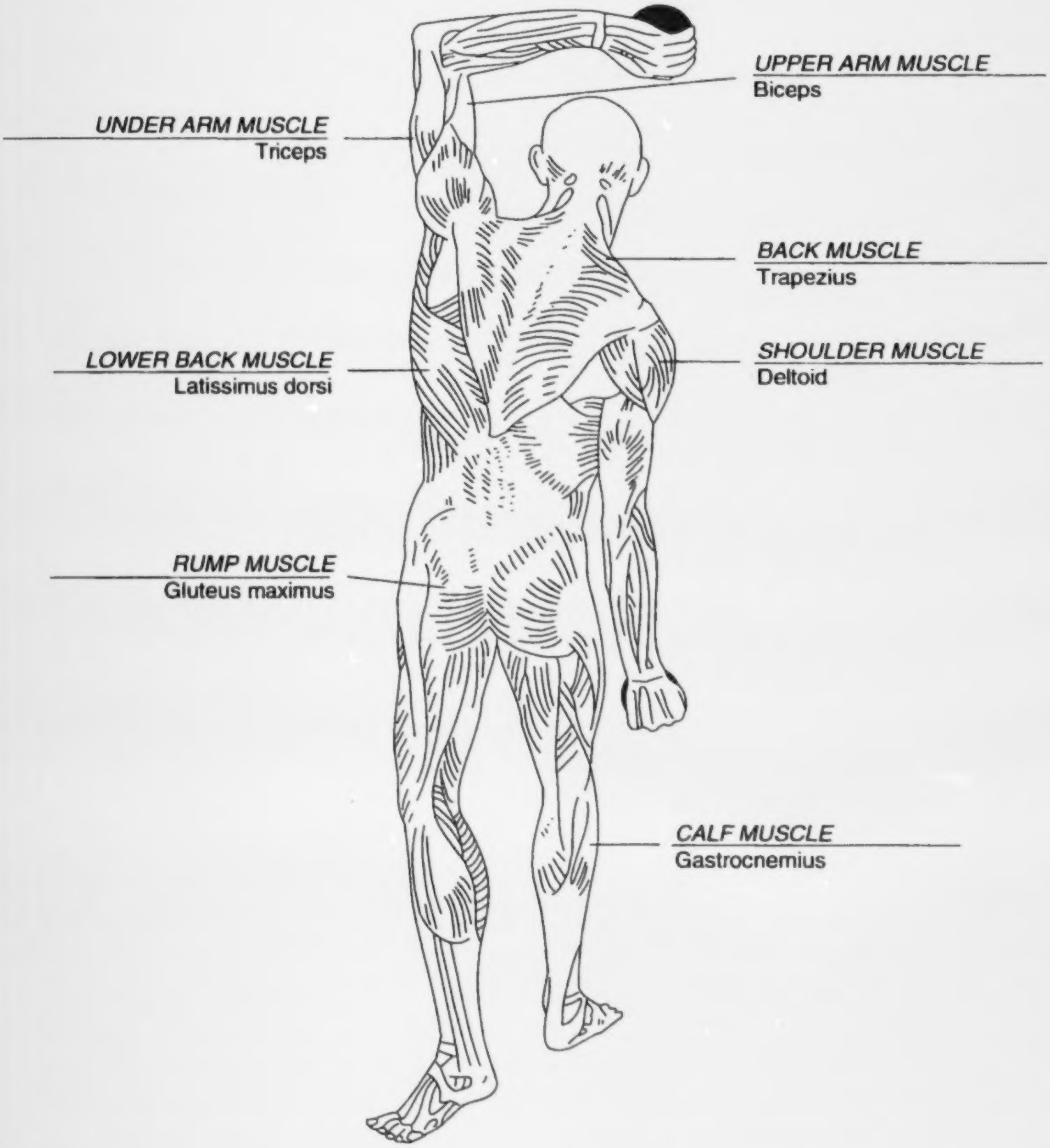

UPPER ARM MUSCLE
Biceps
UNDER ARM MUSCLE
Triceps
BACK MUSCLE
Trapezius
SHOULDER MUSCLE
Deltoid
LOWER BACK MUSCLE
Latissimus dorsi
RUMP MUSCLE
Gluteus maximus
CALF MUSCLE
Gastrocnemius

Figure 5.3.15(2) Common and scientific names of muscles of the body (back view)

Name________________________

Date_________________________

DASH

STUDENT PAGE 5.3.15 MUSCLE NAMES

1. Write the common names for the muscles identified in the Figures SP 5.3.15(1-2).

2. Name the muscles that could

   - Pull the upper arm (the humerus) up.

     ____

   - Pull the upper arm (the humerus) down.

     ____

   - Pull the upper leg (femur) up.

     ____

   - Pull the upper leg (femur) down.

     ____

   - Pull the front of the foot down to walk on the toes.

     ____

   - Pull the front of the foot up to walk on the heel.

     ____

ILLUSTRATIONS

Name ______________________________

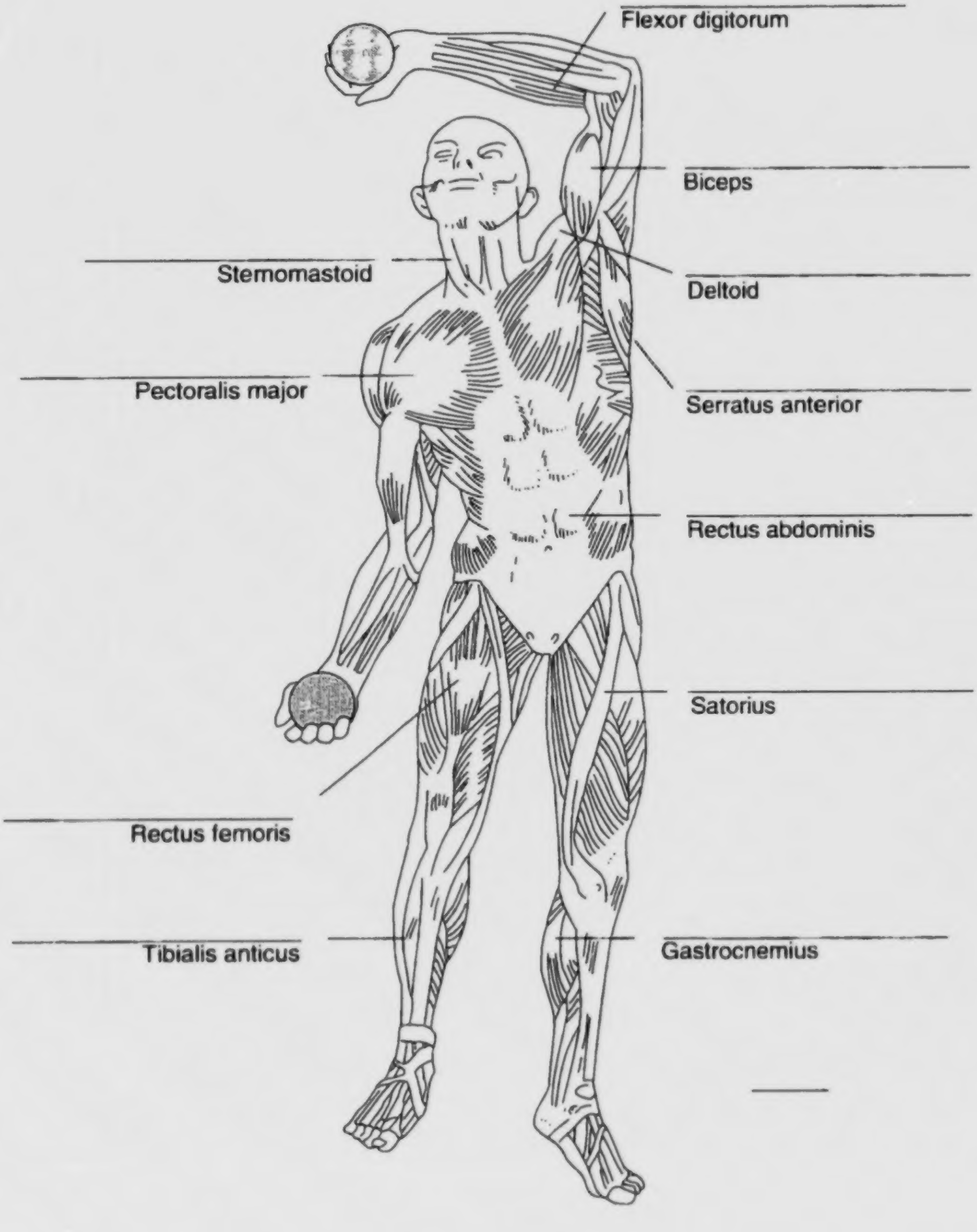

Flexor digitorum
Biceps
Sternomastoid
Deltoid
Pectoralis major
Serratus anterior
Rectus abdominis
Satorius
Rectus femoris
Tibialis anticus
Gastrocnemius

Figure SP 5.3.15(1) Common and scientific names of muscles of the body (front view)

Name ______________________________

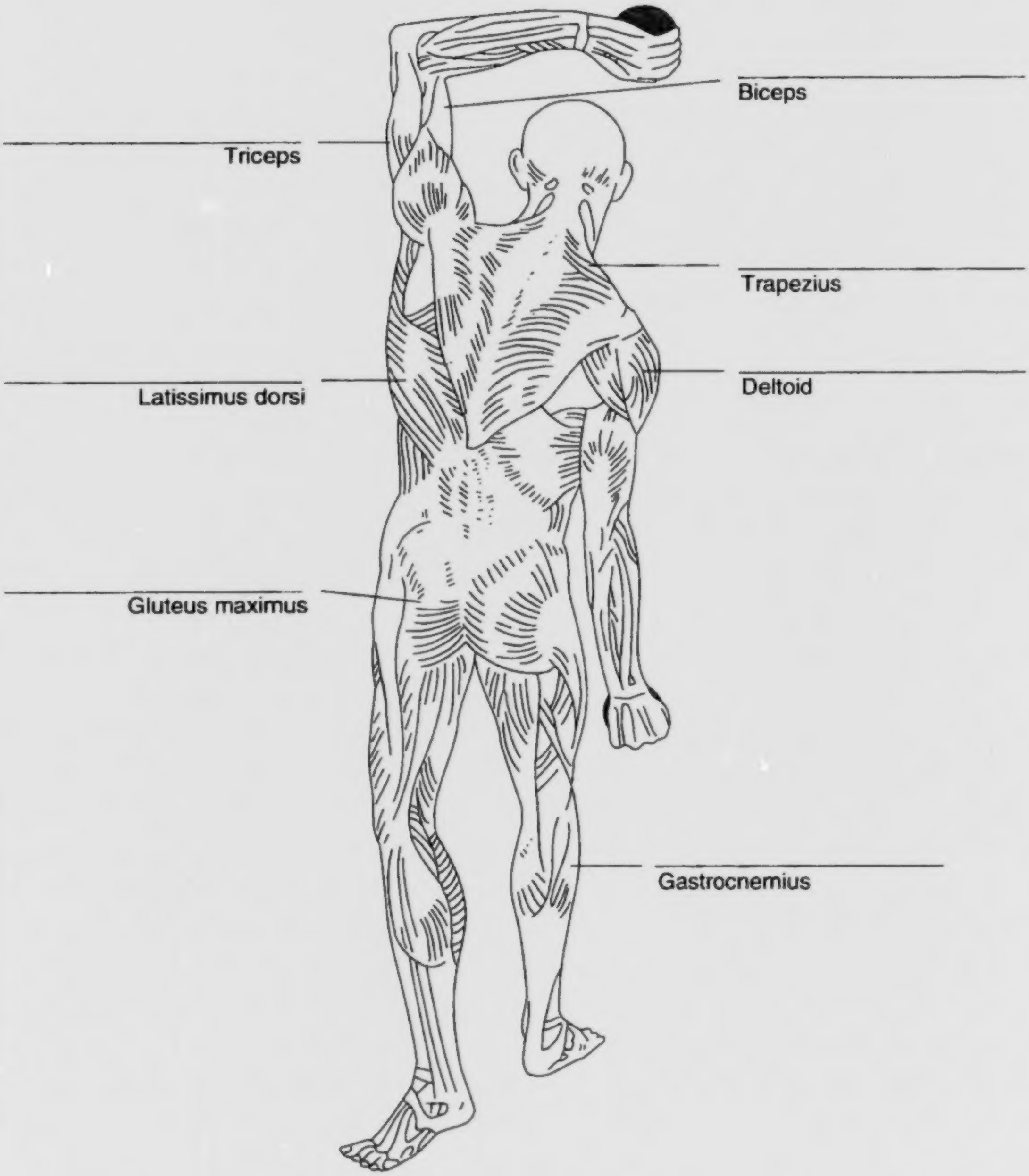

Biceps
Triceps
Trapezius
Deltoid
Latissimus dorsi
Gluteus maximus
Gastrocnemius

Figure SP 5.3.15(2) Common and scientific names of muscles of the body (back view)

ACTIVITY 5.3.16 CHEMISTRY AND BONES

OBJECTIVES

The students
- Investigate digestion of bone, shell, and other animal materials.
- Review the nature of acids and bases.
- Observe changes in the pH of vinegar as it digests bone, shell, and other materials.
- Observe changes in the mass of the bone and other materials undergoing digestion.
- Recover dissolved calcium compounds from the vinegar solution.
- Associate bone and calcium with mineral supplements.

BACKGROUND

In this activity the students investigate possible nutritional values of bone and teeth, shell, coral, tendon, cartilage, muscle, skin, and other animal material. This is a continuation of work done on digestion in DASH 4 and is also a part of the DASH 5 nutrition sequence.

Digesting Acid

In CHEMISTRY AND BONES common kitchen vinegar ($HC_2H_3O_2$) is used as the digesting chemical. Vinegar is an acid. Hydrochloric acid (HCl) is an acid found in the stomachs of animals. Both hydrochloric acid and vinegar ($HC_2H_3O_2$) react with the calcium carbonate ($CaCO_3$) in bone, shell, and coral to break it down into a dissolved calcium compound and to release carbon dioxide gas (CO_2). Both acids react with the protein in bone, tendons, cartilage, skin, and flesh to make it rubbery.

Use large baby food jars as reaction chambers. Pieces of test materials can be broken or cut to fit in the jars.

Bone

Bone is a remarkable material. It is a composite made mostly of calcium carbonate ($CaCO_3$), calcium phosphate $Ca_3(PO_4)_2$, and protein material. When calcium compounds are removed from the bone by the action of an acid, a rubbery protein is left behind. Protein gives our bones their flexibility and helps prevent breakage.

Teeth and Shells

Our teeth also contain phosphate, calcium carbonate, and protein. Acid will react with them in the same way it does with bone. Shell and coral contain little or no protein and are completely decomposed by acid. In our stomachs as in those of many mammals, we can digest both bone and ground-up shells. The calcium is absorbed into our bloodstream and delivered to the living cells of our bone and teeth, which incorporate it into their structure. Ground-up shell is a common source of the mineral calcium sold as a dietary supplement.

Definition of Acids and Bases

DASH students may have worked with acids and bases in other years. They may have

- Observed that acids work in digestion of different foods.
- Worked with citric acid ($H_3C_6H_5O_7$) from citrus fruit and vinegar ($HC_2H_3O_2$).
- Talked about hydrochloric acid (HCl) or stomach acid.
- Worked with bases such as limewater ($Ca(OH)_2$) and solutions of soap and detergent.
- Seen acids reacting with calcium carbonates ($CaCO_3$) and sodium bicarbonate ($NaHCO_3$) to produce the gas carbon dioxide (CO_2).
- Defined *acids* as liquids that have a pH less than 7 and *bases* as liquids that have a pH of more than 7.

Acids, Bases, and pH

By measuring pH one can tell whether a solution is acidic, neutral, or basic. Liquids that are neither acidic or basic have a pH of 7 (neutral) as registered by the color of the pH paper. An example of such a liquid is distilled water. Acids have a pH of less than 7. Bases have a pH of more than 7. A solution with a pH of 10 is more basic than one with a pH of 9, which is more basic than one with a pH of 8. An acid with a pH of 2 is more acidic than an acid with a pH of 3, which is more acidic than one with a pH of 4.

pH Paper

In DASH students use a commercial pH paper to measure the pH of solutions. The pH is registered by a change of color when the paper is touched to a solution. Accompanying the pH paper is a color chart that is matched with the color registered on the paper after it has been dipped into a solution of unknown pH. Each color indicates a different pH.

Materials to Be Digested

In CHEMISTRY AND BONES the students expose hard, tough substances produced by animals to acid. They then compare what happens to these substances in an attempt to find out what might happen during the digestion of bone. The table below gives a summary of probable results.

Table 5.3.16 Expected reactions of animal material with vinegar

	MATERIALS					
OBSERVATION	Bone/ Teeth	Shell	Cartilage	Tendon	Skin	Meat
Visual	Bubbles	Bubbles	Swells	Swells	White	White
Tactile	Becomes rubbery	None	Becomes rubbery	Becomes rubbery	Becomes rubbery	Becomes rubbery
pH Change	Increase	Increase	Increase	Increase	Increase	Increase

STUDENT ROLES

Chemist
Nutritionist

MATERIALS

white vinegar
large and small baby food jars with lids
pH paper
balances
graduated containers
safety masks
aprons
chicken leg bones, raw or cooked
chicken cartilage, raw or cooked
chicken skin, raw
chicken tendon, raw
chicken meat, raw
other bones
teeth, human or other
sea shells
snail shells
coral or limestone
Student Pages 5.3.16 CHEMISTRY AND BONES

PRODUCTS

Completed Student Pages

PROCEDURES

1. **Go back to the concept map about bones developed in Activity 5.3.12 BONES.**

   Ask such questions as these:
   - Are there other things about bone that we can add to our concept map? (Have the students add any they can think of.)
   - Are there other bone-like materials that animals produce? (Work for the idea of the shells of shellfish (oysters and clams), shells of snails, and coral.)
   - When you were eating meat have you ever found any tough, almost hard materials? What are they? (Work for the idea of gristle, cartilage, and tendons.)
   - Have any of you ever eaten bone? (Some may have eaten bone meal. Get a report on how it tastes.)
   - Have any you ever eaten shells? (Some may have eaten calcium supplements made of oyster shell. Get a report on how it tastes.)
   - Dogs eat bone. Do you think they digest it?
   - What do we mean by digestion? (Go back to the Working Dictionary. If digestion does not appear in the dictionary, develop a definition that includes the idea of breaking down foodstuff into chemicals that can be used in the body for *activation, regulation,* and *fabrication.*)
   - How could we find out whether bone and other tough animal materials can be digested? (Develop the idea that we could put these materials in contact with chemicals that are known to digest food.)
   - In our stomach and those of other mammals a major chemical of digestion is hydrochloric acid. Vinegar acts with foods much the same way that hydrochloric acid acts with them. What do you think will happen to hard animal materials that are put in contact with such an acid? (Get predictions.)

2. **Have the students collect or provide them with materials that are the hard and tough products of animals—bone, gristle, tendon, shell, skin, and so forth.**

Have the students
- Wear aprons and eye shields.
- Describe the materials before they start the "digestion."
- Set up a digestion experiment using an Inventor's Box with baby food jars and lids and vinegar.
- Use small pieces of materials that fit on the bottom of the jar. (Size will vary depending on the material.)
- Be sure that the material being digested is well submerged under the vinegar.

3. **Review their recollections of acids and bases.**

Ask such questions as these:
- What is vinegar? (Have the students use their DASH 4 working definitions to answer the question. If they do not have a definition recorded, have them get a standard dictionary definition. Be sure they include the fact that vinegar is an acid.)
- How can we determine whether a solution is acid? (Get at the use of pH paper to determine the pH.)
- What do you think vinegar's pH is? (Record predictions and have the students test and record the pH found. Go over the working definition that an *acid* is a solution that has a pH less than 7.)

4. **Have the students observe the reaction of vinegar and their hard and tough animal materials for a week or until there is no further reaction. When they work with the acid, have them wear eye shields and aprons and wash their hands after they have completed their work.**

Have them record daily
- Observations.
- pH of the solution.
- Mass of the treated materials.

5. **Have the students report on their findings.**

Ask such questions as these:
- What did you observe?
- Did all the materials show the same kind of reactions? (See the table in the Background.)
- What does pH tell us? (Whether a solution is neutral, an acid, or a base.)

- What did an increase in pH mean in our reaction chambers? (That the vinegar solution was becoming less acid—the acid was being used up.)
- What did the decrease in mass mean? (Work to the idea that the amount of material being weighed was getting smaller each time.)
- How does bone seem to differ from shell? (Play on the observation that when the bone was digested, a rubbery material was left behind. When the shell was digested, nothing was left.)
- What might this mean? (That part of the bone might be like shell and part of it is different.)
- What does the material left from the bone look and feel like? (It will often feel and look like rubber or the tendon or cartilage.)
- What has happened to the tooth that was placed in vinegar? (It too will have been dissolved and a pulpy bit of rubbery material will remain.)
- What could have happened to the material in the shell and bone that seems lost? (Work to the idea that the material may have gone off as a gas, it may have gone into the solution, or both.)
- How could we test to see whether any of the material was dissolved in the liquid? (Work to the idea that the liquid could be allowed to evaporate or it could be boiled away.)

6. **Have the students invent a way to evaporate away the liquid without using an artificial heat source. Provide an Inventor's Box with aluminum foil, pans, bowls, sticks, and so forth. Have the students time how long it takes to evaporate away 10 mL of the solution.**

7. **Summarize the activity.**

Ask such questions as these:
- Was there material dissolved in the liquid?
- What did it look like? (A whitish material.)
- What did you do to increase the rate of evaporation? (Students may have done such things as put the solution in the sun, make very thin layers of solution, stir it, direct a fan over the solution, and so forth.)
- Why did you use the technique that you did?
- What do you think happens to bone in the stomach of a dog? (Get at the idea that it would probably be dissolved by stomach acid.)

- Why might we sometimes use bone meal and ground oyster shell as a supplement to our diets? (Introduce the idea that we can use these substances as calcium sources to build our own bone.)
- What is meant by the statement "dogs eat bone to produce bone"?

EXTENSION

- Have the students find out how many the forms of calcium can be found in calcium mineral supplements in the drugstore.

Name__________________________

Date__________________________

DASH

STUDENT PAGE 5.3.16 CHEMISTRY AND BONES

1. List bone-like materials that animals produce in their bodies.

2. Explain what we mean by digestion.

3. Describe the materials to be tested in chemical digestion.

Name______________________________

4. Make a separate data table and daily record for each material tested.

Include
- observations
- the ph of the solution
- the mass of the material

5. Describe how you evaporated away the liquid that remained after the reaction was complete. Explain why you selected the means you chose to speed up the evaporation.

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6. Describe what was left after you completed your evaporation.

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ACTIVITY 5.3.17 THE SENSES

OBJECTIVES

The students
- Identify the major senses.
- Locate the major sensory receptors on their bodies
- Explore the sense of taste.
- Design explorations of sensory receptors in their skin and carry them out.

BACKGROUND

This activity continues the study of the senses that begins in DASH kindergarten. Here the students inventory their senses, determining what is sensed and what organs are used in detection. They also look for evidence that these organs are the true receptors. After testing where sweetness is detected in the mouth, the students are asked to design their own investigation of sensory receptors in the skin. This activity should be followed by Activities 5.3.18 THE EYE and 5.3.20 THE EAR.

Some Possible Explorations

Student-invented explorations can help answer such questions as these:
- What is the distribution of receptors for pressure, temperature, and touch over different parts of the body?
- How sensitive are receptors? For example, when blindfolded, can a student tell the difference between a pile of two pennies and three pennies placed on a finger, on the back of the hand, on the forearm? Can a student detect a temperature difference in two samples of water at 10°C and 15°C or 0° and 10°C with a finger, the palm of the hand, the back of the hand? Can a student detect the tips of two dull toothpicks with points a millimeter apart on the finger tip, palm of the hand, back of the hand, on the forearm?
- Are some people more sensitive than others?

STUDENT ROLE

Physiologist

MATERIALS

powdered sugar
toothpicks
small drinking cups
blindfolds
source of warm or cold water.
thermometers
pennies
Student Page 5.3.17 SENSES

PRODUCTS

Completed Student Pages

PROCEDURE

1. **Have the students make a concept map of the term senses.**

   Help them include such things as these:
   - Parts of the body.
   - An awareness when one senses the presence of something.
   - The body's organs of information reception.
   - Sight and light.
   - Hearing and sound.
   - Feeling of touch.
   - Feeling of pressure and weight.
   - Feeling of temperature, heat, and cold.
   - Smell and odor.
   - Taste and saltiness, acidity, basically, sweetness, bitterness.
   - Feeling of pain.
   - Sensing balance.

2. **Have the students work in groups to list where they think the receptors for each of the senses are located in their bodies. Have them indicate any special organ used in sensing. Have them record their information on the Student Page 5.3.17 SENSES.**

3. Review the students' listing of senses, their location, and reasons for making their statements about location.

Ask such questions as these:

- Where is our sense of sight located? (Work for agreement that it is located in the eye.)
- What does the eye sense or detect? (Work to the idea that it senses different kinds of light.)
- How do we know that the eye is where light is detected? (Explore different answers, coming back to note that when the eyes are closed and covered, we usually have little or no sense of outside light. Some students may have noticed a light spot when they put pressure on their eyeball. This is a false activation of the optic nerve.)
- Where does our sense of sound seem to be located? (Work for agreement that it seems to be located in the ear.)
- What does the ear sense or detect? (Work for agreement that it is sound.)
- How do we know that the ear is where sound is detected? (Again explore different answers, coming back to note that when the ears are closed or covered tightly we have little sense of sound. Some students will have noted that loud sound, in particular, is detectable when the ear is closed. The bones of the head act as auxiliary receptors.)
- Where does our sense of smell seem to be located? (Work for agreement that it seems to be located in the nose.)
- What does the nose sense or detect? (Work for agreement that the nose senses odor. Odors are gases carried through the air. Our noses are gas-detection devices.)
- How do we know that the nose is where odor is detected? (Again explore different answers, coming back to note that when the nose is closed we have little sense of odor. Some students may have noted that odor is detectable when they eat. This is true. Much of what we think of as "taste" is really a detection of odor. Gases or odors enter through the back of the mouth and go to the odor detectors in the sinuses. We have little sense of odor or the richness of food flavor when we have a cold.)
- Where does our sense of taste seem to be located? (Work for agreement that it seems to be located in the mouth.)
- What do we taste? (Work for agreement that we taste food and other things we put in our mouth.)
- How do we know that food is detected in the mouth? (Again explore different answers, coming back to note that we usually

taste things when we are eating or have other things in our the mouth.)

4. **Include senses that the students may have overlooked because the organs of sense are not obvious.**

   Help them include such things as these by asking
   - Where does our sense of balance seem to be located? (Work for agreement that it seems to be located in the head.)
   - What does our sense of balance detect? (Work for agreement that it helps us know when we are standing straight or tipping over.)
   - Where is our sense of pressure located? (Work for agreement that it seems to be located throughout the body.)
   - How do we know that pressure is detected throughout our body? (Everywhere we press we can feel the push.)
   - Are there other senses that are present over our entire body? (Work for agreement that both temperature and touch are sensed over our entire body.)

5. **Have the student explore their mouth to find what parts are associated with taste of sweetness. Have them wash their mouth with fresh water between tests.**

   Have them
   - Use a wet toothpick touched to powered sugar.
   - Touch various parts of the inside of the mouth to find where sweetness seems to be detected. (Have them touch the walls and the roof of the mouth, under the tongue, and other places on the tongue.)
   - Record where sweetness seems to be most keenly detected.

6. **Summarize the sweetness investigation with the students.**

   Ask such questions as these:
   - Where were you able to detect sweetness? (Work for agreement that it was detected almost exclusively on the tongue.)
   - How might you test to see whether the tongue is the only place in the mouth where taste is detected? (Work for agreement that we could do the same thing with other foods that we did with sugar.)

7. **Have the students develop their own questions about the senses in the skin and have them test them out. See the Background for suggestions.**

8. **Summarize the activity with the students.**

Ask such questions as these:

- What things can we detect that are outside our body? (Review the things the senses detect.)
- Do we all have the same ability to use our senses? (Note the variability in the detection of pressure, temperature, and so forth.)
- What advantages might there be in having the ears and eyes in the head? (Get at such ideas as protection and greater visibility and hearing range when sense organs are above the ground.)
- What advantages might there be in having pressure and temperature receptors over the entire body? (Get at the idea that because pressure and temperature differences occur over our entire body, having many detectors allows us to know when different parts of the body are in danger.)

EXTENSION

- Have the students further explore the tongue for sensitivity. This investigation should be interesting because the tongue can detect only sweetness, bitterness, and saltiness. It is our capacity to sense odor that we rely on heavily in discriminating between different foods.

Name____________________________

Date____________________________

STUDENT PAGE 5.3.17 SENSES

1. List the senses of the body.
   - Indicate where you think each of the senses is located in your body.
   - Indicate any special organ used in the sensing process.

SENSES	BODY LOCATION	SPECIAL ORGAN

2. Describe how you explored the sense of taste and what you found.

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Name______________________________

3. **Describe your investigation of sensory receptors in the skin.**

ACTIVITY 5.3.18 THE EYE

OBJECTIVES

Have the students
- Make a concept map of the term eye.
- Label drawings of the eye.
- Observe the function of the iris of the human eye.
- Make a model of the eye.
- Explain the structure and workings of the eye.

BACKGROUND

THE EYE is part of a series on senses. In this activity the students construct a model to investigate the workings of the eye. The activity should be preceded by Activities 5.10.3 CAMERA OBSCURA and 5.10.4 CONTROLLING LIGHT WITH LENSES, which investigate lens systems, and Activity 5.3.17 THE SENSES.

Approach

The students first do an exploration, then they read about the structure of the eye. They then extend their earlier exploration of lenses to find that the more bulged a convex lens is, the closer an object can come to it and still be in focus.

The Extensions section outlines an exploration of eyeglass lenses that would be suitable for an activity center.

STUDENT ROLES

Optician
Optometrist
Physicist

MATERIALS

round balloons
shoe box
lenses (hand lenses or other lenses with a short focal length)
black paper
waxed paper
tape
old cameras that can be focused

eyeglass lenses with correction for nearsightedness and farsightedness

Student Pages 5.3.18A THE EYE
5.3.18B EYE PARTS

PRODUCTS

Models of the eye
Completed Student Pages

PROCEDURES

1. **Help the students make a concept map of the term eye.**

   Help them include such things as these:
   - An organ to sense light.
   - An organ found in many animals.
   - Found in the head.
   - Seems to be round.
   - Has a lens.

2. **Have the students inspect each other's eyes and describe, draw, and label them. Have them use Student Page 5.3.18A. As you discuss their drawings, give names to the parts.**

   Ask such questions as these:
   - What parts did you see? (Expect such things as eyelids and eyelashes as well as the white of the eyeball *[the scelera],* the colored ring *[the iris],* and a dark circle *[the pupil].* Name these parts if students haven't.)
   - What were the colors of the eye parts? (The only common color will be the white of the eyeball.)
   - Did anyone see blood vessels? What did they look like?
   - Where were the blood vessels? (Work for agreement that they were on the white of the eyeball.)

3. **Help the students investigate the function of the iris of the eye while working with partners.**

   This can be done in the following way:
   - Have half the student partners face a window when the outdoor lighting is bright. A brightly lighted screen can be substituted for natural light.

- Have these partners close their eyes for a minute or two.
- Have the other partners watch what happens to the iris or colored ring of the eye when the eye is opened while looking into the bright light. (The iris should rapidly reduce the size of the pupil.)
- Have the students exchange roles without telling their partners what they saw.
- Ask whether it hurt just a little when they first looked at the bright light? (Usually, many will say it did.)
- What seems to be the function of the colored muscular ring around the dark circle in the center of the eye? (Work for agreement that it could reduce the amount of light getting into the eye. This may be why the eye no longer pains after we look at bright light for some time.)

4. **Have the students read Student Page 5.3.18B EYE PARTS and label the diagram in Student Page 5.3.18A THE EYE. See Figures 5.3.18(1–2).**

Help the students
- Label the parts of the inner eye.
- Suggest a function for each of the parts.

5. **Have the students make a box model of the eye. Have them use a waxed-paper screen as the retina so that the image can be viewed from the rear. See Figure 5.2.18(3) for a prototype. Provide an Inventor's Box with shoe boxes, waxed paper, lenses, tape, and dark paper.**

6. **Have the students demonstrate their box models of the eye and explain how they work.**

Ask such questions as these:
- How does your iris work?
- Does your lens bring objects at a distance to a focus on the waxed paper retina?
- Does your eye model bring all things to focus on the waxed paper retina? (It cannot because it is a solid lens with a fixed focal length.)

7. **Provide the students with two or more convex lenses that have approximately the same diameter but different thicknesses.**

Have the students
- Put thin lenses in the model eye.
- Use an electric light bulb as an image.
- Adjust the screen so that the image of the bulb is clear when the bulb is 2 to 3 meters away
- Measure the distance from the model to the bulb.
- Predict whether the distance between the model and the lens will be longer or shorter when a thicker lens is substituted for the thin lens.
- Test their predictions. (The distance from the model to the bulb will be shorter when they use the thick lens.)

8. **Summarize work with the models.**

Ask such questions as these:
- In our model what kind of lens would we use to see distant objects? To see objects that are nearer? (Work to the idea that a thinner lens provides clarity of distant objects; a thicker lens, of nearer objects.)
- If we put water in a balloon to simulate the liquid in our eye's lens, how could we make the balloon fatter or thicker? (Have the students use a balloon partially filled with water to represent a flat lens. Ask how it could be made to bulge more. This can be done by making the fingers of the hands into a circle pushing in on sides of the balloon. See Figure 5.3.18[4].)
- What might do this in the eye? (Help the students find the muscles around the lens in their diagram.)
- How might the muscles operate to flatten the lens? (Again demonstrate with the balloon, showing how it flattens when the side expands and bulges when the sides contract. A similar flattening and bulging of the eye's lens could result from the contracting and relaxing of eye muscles about the lens.)
- Why might working with things very close to the eye tire it? (Get at the idea that the muscle that causes the lens to bulge would have to work constantly.)
- There are some people who can clearly see only things that are close to their eyes. They are said to be *nearsighted.* What might their problem be? (Work to the idea that their lens may not flatten out enough for distance viewing. Another explanation might be that their retina is too far from the lens. See Figure 5.3.18[5].)
- There are some people who can clearly see only things that are far away from their eye. They are said to be *farsighted.* What

might their problem be? (Work to the idea that their lens might not be able to bulge enough. Another explanation might be that their retina is too close to the lens.)

EXTENSIONS

Have the students

- Invite an optician or optometrist to speak about working with people who have vision problems.
- Research ways the eye is now being repaired.
- Use eyeglass lenses that are corrected for nearsightedness and farsightedness with an eye model to see how they help compensate for the conditions.

ILLUSTRATIONS

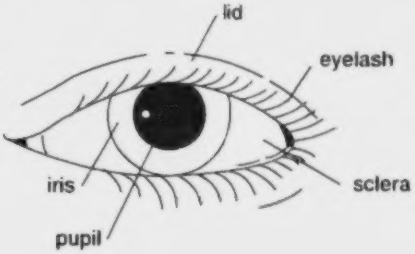

lid
eyelash
iris
sclera
pupil

Figure 5.3.18(1) The eye as it is normally seen

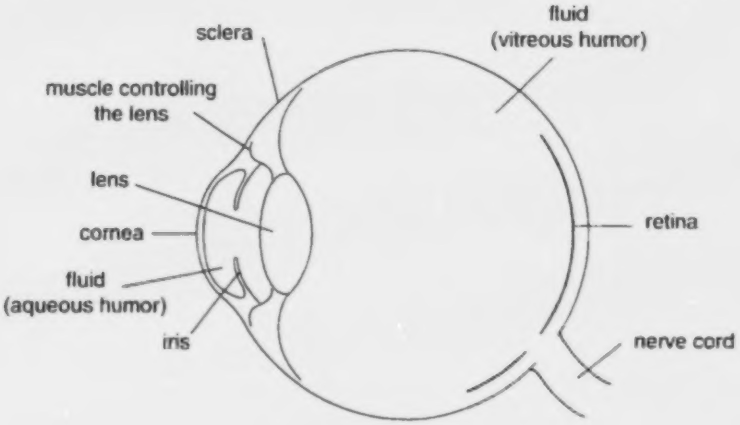

sclera
fluid
(vitreous humor)
muscle controlling
the lens
lens
cornea
retina
fluid
(aqueous humor)
iris
nerve cord

Figure 5.3.18(2) The dissected eye

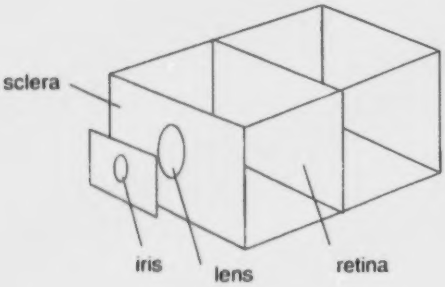

sclera
iris
lens
retina

Figure 5.3.18(3) Box model of an eye

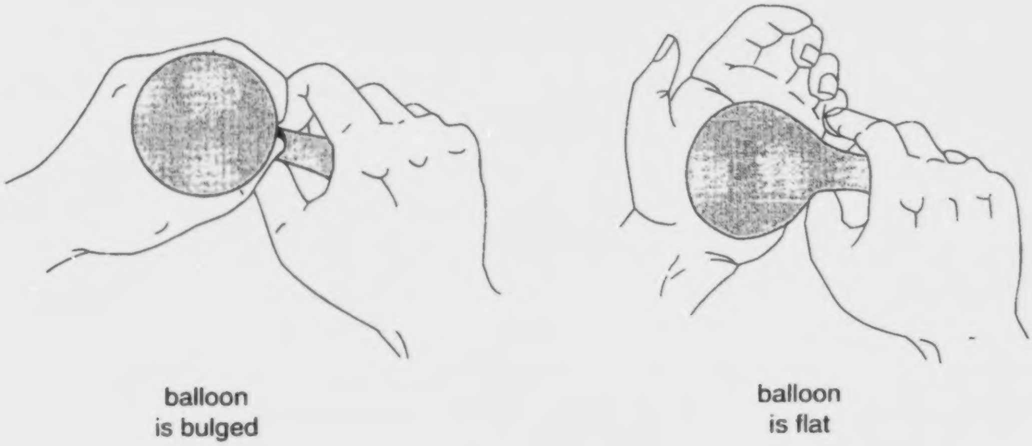
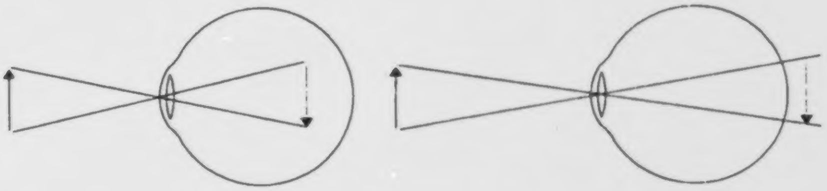

balloon
is bulged
balloon
is flat

Figure 5.3.18(4) Balloon model of the bulging lens



Nearsighted

The lens does not flatten enough for the eye to see distant objects. The clear image falls in front of the lens.

Farsighted

The lens does not thicken enough for the eye to see near objects. The clear image falls behind the lens.

Figure 5.3.18(5) Nearsighted and farsighted eyes

Name__________________________

Date__________________________

DASH

STUDENT PAGE 5.3.18A THE EYE

1. Draw your partner's eye and other body parts that help in sight and protection. Label these parts.

2. Describe what the colored ring (the iris) does in response to intense light.

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Name______________________________

3. Label the diagram of a dissected eye.

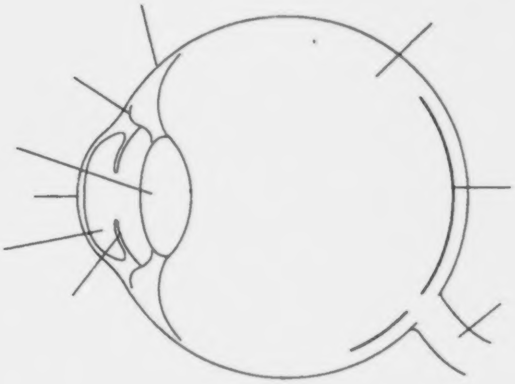

Figure SP 5.3.18A The dissected eye

4. Draw your box model of the eye, label the parts, and explain how it works compared to a real human eye.

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5. **Describe how thick and thin lenses of the same diameter differ in their focal lengths.**

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6. **Explain how the eye adjusts to keep both things at a distance and things that are close at hand in focus.**

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Name________________________

Date________________________

DASH

STUDENT PAGE 5.3.18B EYE PARTS

PARTS OF THE EYE

- **The cornea** is the clear protective window through which light enters the eye. It forms a slight bulge at the front of the eyeball.
- **The iris** is a colored muscular ring around the pupil of the eye. It controls the amount of light that can enter the eye. It is the iris that gives our eyes their color.
- **The pupil** is the opening in the center of the iris through which light passes to the lens. We see it as a dark circle in the center of the eye.
- **The lens**, called the crystalline lens because it is as clear as crystal, is directly behind the iris and acts to focus light on the retina, the light-sensitive part of the eye.
- **The lens muscles** adjust the thickness of the lens and allow it to change its focus.
- **The sclera** is the tough outer protective covering of the eyeball. We see it as the "white of the eye."
- **The retina** is at the back of the eye opposite the pupil. It is the "screen" on which light is focused by the lens. The retina is a vast bed of nerve endings that pick up the image focused on it. These nerve endings are able to distinguish between different colors of light.
- **The optic nerve** is the carrier of visual information from the retina to the visual centers of the brain.
- **The fluid in *front* of the lens** is a clear, watery liquid that helps hold the shape of the cornea and protect the lens and inner parts of the eye from sudden blows. It is called the ***aqueous humor***.

Name________________________

- **The fluid *behind* the lens** is a thick, transparent jelly that holds the shape of the body of the eyeball and takes up the impact of sudden blows. It is called the ***vitreous humor***.
- **Tear glands** are located above the eyeball on the ear side of the eyelid. These glands produce the liquid that washes foreign matter from the eye.
- **Tear canals** have openings on the inner or nose side of the eyelids—one on the upper and one on the lower lid. We can see two openings—one above and one below on the eyelid. These openings drain tear fluids into our nose. This is why that we must blow our nose when we cry.
- **Eyelids** are muscle-operated flaps of skin that can be brought over the eye to close it.
- **Eyelashes** are hairs growing on the rim of the eyelid. These hairs help protect the eye against the entry of foreign bodies.

ACTIVITY 5.3.19 SOUND

OBJECTIVES

The students
- Make a concept map of the term sound.
- Make a device to generate a loud and a long-lasting sound.
- Invent a way to deaden the sound produced by their device.
- Develop and test a hypothesis about how sound is produced.
- Develop a working definition of the term sound.

BACKGROUND

This activity introduces the topic of sound, which will be continued in Activity 5.3.20 THE EAR.

Approach

In SOUND the students record their existing understanding of sound and use items from the Inventor's Box to make devices that will give them the loudest and the longest-lasting sound possible. Next, they try to deaden the sound produced by their device. Finally, they invent an explanation of sound and test it.

Nature of Sound

A sound wave is started by a vibrating object. As the object vibrates, it alternately compresses then decompresses the medium that carries it. That medium may be solid, liquid, or gaseous. These regions of compression and decompression travel through the medium and are called *sound waves.* For example, we can secure one end of a meterstick or ruler and bend it back so that it will vibrate and create movement in the air. This movement of air can be felt on our hand as a series of little gusts or compressions. These gusts spread out and move in all directions from the meterstick. These are sound waves. As the number of vibrations in the air increases, we can no longer sense the individual gusts on our hand, but our ear can sense them. We start to hear sound at about 16 vibrations per second. The normal human ear senses a range of vibrations from 16 to 20,000 per second.

Sound Transmission

Once a sound wave has been produced, it moves through a medium rapidly. The speed of sound is variable, depending on the transmitting medium. A table of some speeds of sound is shown below.

Table 5.3.19 Speed of sound

Medium	Meters/second	Feet/second
Air	332	1,090
Aluminum	5,106	16,750
Glass	5,030	16,500
Iron	5,030	16,500
Water	1,408	4,620
Wood	4,359	14,300

Sound can be transmitted through the string of a string telephone, the water in a swimming pool, or the air trapped in a stethoscope. Sound can be heard by placing the ear against the wood in a door, the rail of a track, even against the floor or hard earth.

Probable Student Explanations

When the students invent an explanation of how sound is produced, they will normally come up with the idea that sound is a vibrational phenomenon with one or more of the following characteristics:

- Can be felt by touch.
- Can be seen when sound makers are put into a medium such as water where waves will form.
- Can be transmitted to something else. (The string of a musical instrument such as a guitar, violin, or piano makes its resonator box vibrate.)

STUDENT ROLES

Physicist
Sound engineer

MATERIALS

tin-can lids
metal bars
pie pans
tape
marbles
metersticks
blocks of wood
paper bags
rubber bands
hacksaw blades
wooden rulers
tacks
paper
plastic bags
Styrofoam
tape
cloth
Student Page 5.3.19 SOUND

PRODUCTS

Sound-generating devices
Completed Student Pages

PROCEDURES

1. **Have the students make a concept map of the term sound.**

   Help them include such things as these:
   - What we hear.
   - Music.
   - Voices.
   - Noise.
   - Stethoscopes.
   - Megaphones.
   - String telephones.

2. **Have the students invent a way of making sounds as loud or long-lasting as possible from objects in the Inventor's Box. The sound should be made by a single blow, shake, strumming, and so forth. Hold a "loudness contest" and a "longest-lasting sound contest."**

   In the Inventor's Box include such things as these:
   - Tin-can lids.
   - Metal bars.
   - Pie pans
   - Tape.
   - Marbles.
   - Blocks of wood.
   - Paper bags.
   - Rubber bands.
   - Hacksaw blades.
   - Wooden rulers.
   - Tacks.

3. **Have the students take the device they have used to make a loud or long-lasting sound and invent a way to deaden that sound. Again use the Inventor's Box. Hold a "sound-deadening contest."**

   Add such things to the Inventor's Box as these:
   - Paper.
   - Plastic bags.
   - Styrofoam.
   - Tape.
   - Cloth.

4. **Summarize the study of sound to this point.**

   Ask such questions as these:
   - What made the loudest sound? (The answer to this will be variable, depending on what the students did.)
   - Could you have made an even louder sound with the same objects? (Usually the intensity of the sound is a result of the amount of energy we use. The energy used here would usually be in the form of energy of movement—the force we use in hitting a tin can, breaking an air-filled bag, shaking a rattle, and so forth. If we were using an explosive such as gunpowder, the amount of energy involved would be determined by the amount of chemical energy in

the explosive; in other words, the more gunpowder, the louder the noise.)

- What made the longest-lasting sound? (The answer to this will be variable, depending on what the students did.)
- What could you do to get the sound produced by the device to last even longer? (Usually this will be a matter of putting more energy into the device.)
- What was the best way to deaden the sound? (This answer will be variable, depending on the device and what was tried as a deadening agent.)
- Could you have deadened the noise even more? (Usually the answer will involve adding more deadening material. A student who thinks that sound travels through air may make suggestions about removing the air.)
- How does noise seem to be made? (Have the students state and discuss their hypotheses about how sound is produced.)

5. **Help the students develop hypotheses about how sound is produced and invent ways to test them. Give them a deadline of two to three days to develop their hypotheses and tests.**

    - Provide an Inventor's Box with the materials previously used. Add items as requested.
    - Have the students work with materials to explore ideas either in groups or individually.
    - Encourage the students to use references for ideas if they choose.

6. **Have the students report on their hypotheses and demonstrate how they tested them. Have them discuss each hypothesis.**

7. **Help the students extend and further test their hypotheses.**

    Ask such questions as these:

    - How might a wooden meterstick or a ruler be made to produce a sound? (Have the students attempt to get sound out of a meterstick or ruler. Have them demonstrate what they have found. It may be necessary to shorten the meterstick before a sound will be produced. See Figure 5.3.19.)
    - Does your hypothesis explain this making of sound? How? (Normally the students who will most readily explain the making of sound will be those dealing with vibration.)

- How might sound get from the stick to our ear? (Accept all explanations and demonstrations.)
- What fills the space between our ear and the stick? (Work to the idea that there is air.)
- Did anyone feel air moving when the stick was released? (Have the students investigate this.)
- Does this help us in our explanation of sound? (Go back and review the students' hypotheses.)
- What do you feel when your hand is on a desk and someone strikes the desk with a fist or a stick?
- What do you feel when a rubber band held in your fingers is plucked?
- What do you feel when a pipe you are holding is stuck with a hammer?
- Does your hypothesis explain these feelings and the making of sound? How? (Normally the students who will most readily explain will be those dealing with vibration.)
- Does your hypothesis explain how sound is deadened? How? (Normally the students who have been dealing with vibration and where it is stopped or reduced will respond most readily.)
- Does your hypothesis explain a string telephone, a stethoscope? How? (The first involves transmission of voice vibrations over string. The second involves sound transmitted to the ears through the air in a tube.)

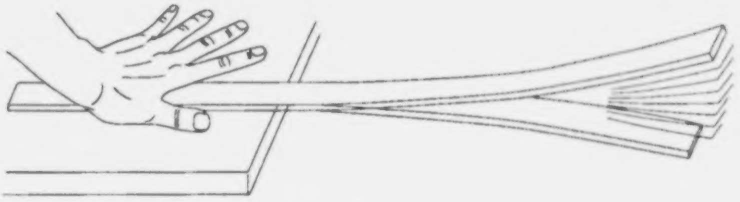
8. **Have the students develop a working definition of the term sound.**

Help them include such ideas as these:
- Sound seems to be produced by things that vibrate.
- Sound is registered in the ear.
- Sound seems to be carried to the ear by air or other media.

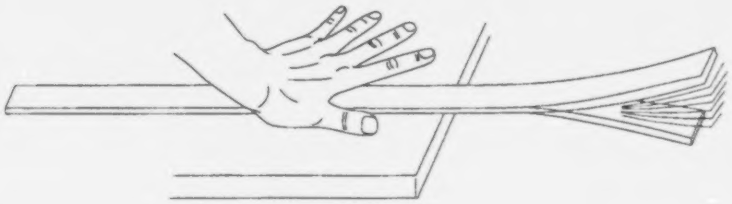
EXTENSION

- Have the students use their rulers or metersticks to play a tune such as *Mary Had a Little Lamb* or the *Farmer in the Dell.*

ILLUSTRATION



making a low-pitched sound using a meterstick extended about 80 cm beyond the edge of a table



making a higher-pitched sound using a meterstick extended about 30 cm beyond the edge of a table

Figure 5.3.19 Producing sound with a meterstick

DASH

Name________________________

Date________________________

STUDENT PAGE 5.3.19 SOUND

1. Draw your device that produces a loud sound and explain how it works.

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2. Draw your device that produces long-lasting sound and explain how it works.

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Name______________________________

3. Describe how you deadened the sound made by your device.

4. Record your hypothesis about how sound is made.

5. Describe how you tested your hypothesis about how sound is made.

6. Explain what you finally concluded about how sound is made.

ACTIVITY 5.3.20 THE EAR

OBJECTIVES

The students
- Examine and draw the external ear of their partner.
- Read a description of the human ear.
- Construct a model of the human ear.
- Discuss the function of the eustachian tube.
- Discuss ear hygiene.

BACKGROUND

The ear is a difficult body structure for students to conceptualize because they cannot see the middle and inner ears. In this activity the students investigate the external ear, read about the middle and inner ears, and then make a model of the ear that involves another example of a lever. The activity concludes with a brief section on ear hygiene. The activity should follow Activities 5.8.5 LEVERS: WHERE ARE THEY? and 5.3.19 SOUND.

Descriptions of the ear and the functions of its parts can be quite complicated. In this activity the emphasis is on hearing, and only the ear's more prominent structures and their functions are described in detail. Understanding of how these structures work will be of value when the students need to talk to a doctor about ear problems.

Special Parts

The common parts of the ear that are directly associated with hearing are described in Student Page 5.3.20A FACTS ABOUT THE EAR. The ear also houses organs of balance or equilibrium—the utricle and the semicircular canals.

- The *utricle* is a balloon-like structure out of which spring the three semicircular canals. In the utricle's walls are specialized cells that sense changes in the position of the head or the body's movement right and left as well as up and down. These specialized cells have hairs that detect the movement of small calcium carbonate particles called *otoliths* that are suspended in a gelatinous mass.
- The semicircular canals are connected to the top of the utricle. There are three of them each at right angles to the others. When the body moves in any direction, movement of fluid over a hair bed in the canal is detected. In this manner the brain is able to register body movement.

STUDENT ROLE

Physiologist

MATERIALS

flashlights (optional)
pins
scissors
corrugated cardboard
knife to cut corrugated cardboard.
Student Page 5.3.20A FACTS ABOUT THE EAR
5.3.20B THE EAR

PRODUCTS

Models of the ear
Completed Student Pages

PROCEDURES

1. **Have the students inspect and draw a partner's ear. Have them go outdoors or use flashlights so that they can get light into the ear canal. Have them record their drawing on the Student Page 5.3.20B THE EAR.**

   Ask such questions as these:
   - What is the shape of the external *pinna* or flap of the ear? (Work for agreement that it is shaped something like a question mark or the letter *C*.)
   - Are all ears shaped the same? (There will be considerable variability.)
   - What did you find inside the pinna? (Work for agreement that there is a tunnel or *canal* leading from the outside.)
   - What is at the end of the canal? (Probe for the idea that there seems to be a wall. Have the students label this the *eardrum*.)
   - What do you think the pinna might be used for? (Get at such things as catching sound, protecting the inner ear, and so forth.)

2. **Have the students explore the function of the external ear or pinna.**

Have them
- Cup their ear while listening to someone talking softly, then release it.
- Make a conical ear trumpet out of paper and use it to listen to someone talking softly.

3. **Discuss their findings.**

Ask such questions as these:
- What do dogs do when they are listening attentively? (Work for agreement that they perk up their ears.)
- How do the cupping of an ear, the use of an ear trumpet, and the perking up of dogs' ears seem to be related to the pinna or external ear of the human? (Work to the idea that they all seem to help collect sound.)
- What would you expect to find behind the eardrum? (Accept all hypotheses.)

4. **Have the students read Student Page 5.3.20A FACTS ABOUT THE EAR and label the parts of the ear diagram in Student Page 5.3.20B THE EAR.**

Ask such questions as these:
- How can the vibration from the eardrum be transmitted to the cochlea? (Work for agreement that the hammer, anvil, and stirrup are connected, and vibration is transmitted through them.)
- If the hammer and the anvil are two levers connected at the head of the hammer and the bulge of the anvil, how might vibration be transmitted?

5. **Have the students construct a model of the ear showing movable lever system made of the bones of the middle ear.**

Have the students
- Cut out the outlines of the bones of the middle ear and the eardrum found in Figure SP 5.3.20B.
- Cut out the diagram of the ear and mount it on corrugated cardboard. Place the ear-bone lever system in the middle ear chamber.
- Fold up the darkened tabs representing the eardrum and the oval window.
- Use a pin as a fulcrum.

6. **Discuss the model of the ear.**

   Ask such questions as these:
   - Using your model, how does the oval window in the cochlea move when the eardrum is pushed inward? (The same way that the eardrum moves—it is pushed inward.)
   - Using your model, how does the oval window in the cochlea move when the eardrum is pushed outward? (The same way the eardrum moves—it is pushed outward.)

7. **Have the students hold their hand above their head and slowly lower it toward their scalp. Have them explore to find how far away their hand is from the their scalp when they feel its approach.**

   Ask such questions as these:
   - When do you feel the hand approaching the scalp? (Work toward agreement that the hand is first felt when it just brushes the hair.)
   - What advantage could this be to us? (Work to the idea that it is like an early warning system about incoming objects.)
   - Does other hair on your body react the same way? (The students will find that the hair on their arms reacts the same way.)
   - How is this like the detection of motion in your ear?

8. **Have the students swallow and notice what happens in their ears.**

   Ask such questions as these:
   - How do your ears feel when you swallow? (They may register a bit of a roaring sound.)
   - Have your ears ever felt uncomfortable when you went up or down a mountain in a car?
   - What did you do to make them feel better? (Chewed gum, yawned, swallowed.)
   - What do you think happens when you swallow? (Work to the idea that swallowing opens the eustachian tube so that air can flow in.)

9. Discuss ear hygiene.

Ask such questions as these:

- What can one do to help an earache? (Get at the importance of seeking medical help. Point out that most earaches can be treated effectively with antibiotics if caught early enough.)
- Where is the infection when we get an earache? (It almost always will be found in the middle ear. Work to the idea that germs can enter through the eustachian tube.)
- What happens when one does not treat an inner earache and it persists for a long time? (Hearing can be permanently impaired. The eardrum can burst. Inner-ear infection is called *otitis media*.)
- Is wax in the ears natural? (Yes, it seems to be a way of cleaning and protecting the ear.)
- How can one get wax out of the ear? (The best way is with an ear-washing kit. The use of cotton-tipped swabs is not recommended. If wax is persistent, see a doctor to have it removed.)
- Why is it dangerous to put objects in the ear to clean it? (There is the possibility that the eardrum can be damaged.)

EXTENSIONS

Have the students

- Research repair and compensating devices for damaged ears.
- Invite an ear specialist to discuss the ear with the class.
- Research the ways ears are now being repaired.

ILLUSTRATION

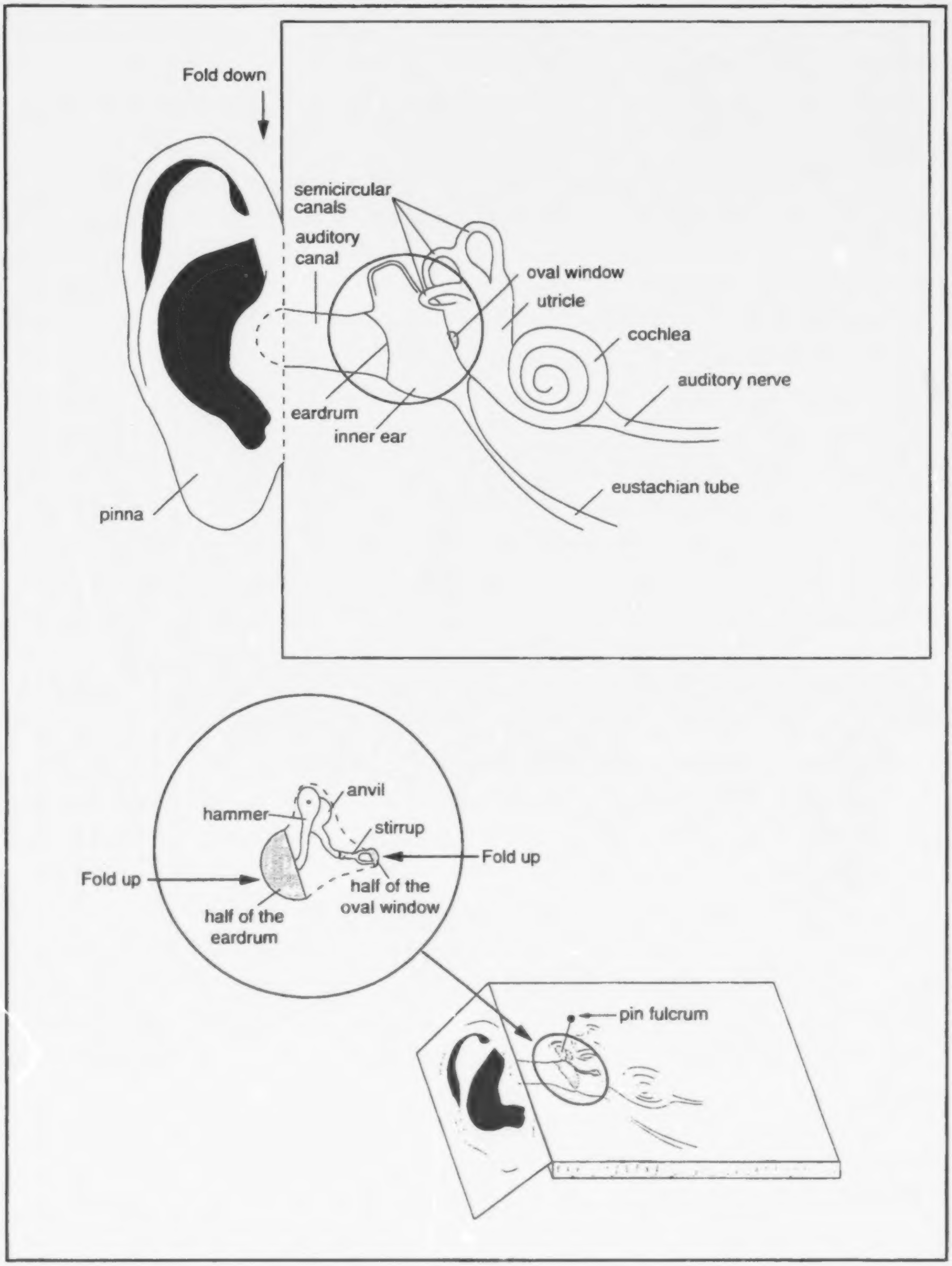
Fold down
semicircular canals
auditory canal
oval window
utricle
cochlea
auditory nerve
eardrum
inner ear
eustachian tube
pinna
anvil
hammer
stirrup
Fold up
Fold up
half of the oval window
half of the eardrum
pin fulcrum

Figure 5.3.20 Working model of the ear

DASH

Name__________________________

Date___________________________

STUDENT PAGE 5.3.20A FACTS ABOUT THE EAR

SOME FACTS ABOUT THE EAR

1. We humans can hear sound made by an object vibrating as few as 16 vibrations per second.
2. Some very young children can hear sound made by as many as 40,000 vibrations per second.
3. As we grow older, we lose our ability to hear these high-pitched sounds, and our upper range drops to about 20,000 vibrations per second.
4. Dogs hear sound made by 30,000 vibrations per second. High-pitched whistles that most of us cannot hear can be used to call them.
5. Our **outer ear** or **pinna** is a sound collector. It sends sound down the **auditory canal** to the **eardrum**.
6. Our **eardrum** is a thin covering at the far end of the auditory canal that vibrates back and forth when sound waves hit it.
7. The eardrum separates the outer ear from the **middle ear**.
8. Our **middle ear** is a small chamber in the bone of the skull between the outer ear and the **inner ear**.
9. The **inner ear** is in another set of chambers even deeper in the skull.
10. Separating the middle ear from the inner ear is a membrane surrounding the structures of the inner ear.
11. Three bones in the middle ear connect the eardrum with the membrane of the inner ear.
12. Attached to the center of the eardrum is a tiny bone called the **hammer**.
13. The hammer in turn is connected to a bone called the **anvil**, which is connected to a bone called the **stirrup**.
14. The inner ear has two purposes, sensing sound information for our brain to interpret and sensing our body's balance.
15. The sensing of sound occurs in the **cochlea**, a snail-shaped tube filled with liquid. *Cochlea* means *snail* in Latin.

Name ____________________

16. The stirrup is attached to the inner ear membrane at a spot called the **oval window,** which is located on the surface of the cochlea. The stirrup carries the vibrations from the eardrum to the fluid in the cochlea.
17. When the eardrum vibrates, the fluid vibrates.
18. Movement in the fluid is detected by tiny hairs in the wall of the cochlea.
19. Additional structures called the **semicircular canals** and the **utricle** are involved in sensing balance.
20. There is a tube running from the back of our mouth to the middle ear. It is called the **eustachian tube**. This tube helps keep the pressure of air on the inside of the eardrum the same as the pressure on the outside of it.
21. Information about sound is transmitted to the brain through the **auditory nerve**.

DASH

Name________________________

Date________________________

STUDENT PAGE 5.3.20B THE EAR

1. Draw the external ear of your partner. Label the parts. Estimate the depth of the canal.

2. Describe how you made your conical ear trumpet out of paper and the effect it had when you listened to someone talking softly.

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Name______________________________

3. Label the parts of the ear using the names found in Student Page 5.3.20A FACTS ABOUT THE EAR.

4. Use the diagram in Figure SP 5.3.20B to construct a model of the ear by cutting out the parts.

- **Cut out the parts of the ear and mount them on corrugated cardboard.**
- **Fold the eardrum and the oval window up so they form a 90° angle with the ear-bone system (hammer, anvil, and stirrup).**
- **Attach the ear-bone system in the middle-ear chamber of the model. Use a pin or tack as the fulcrum.**

5. Describe how the inner ear operates.

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ILLUSTRATION

Name ______________________

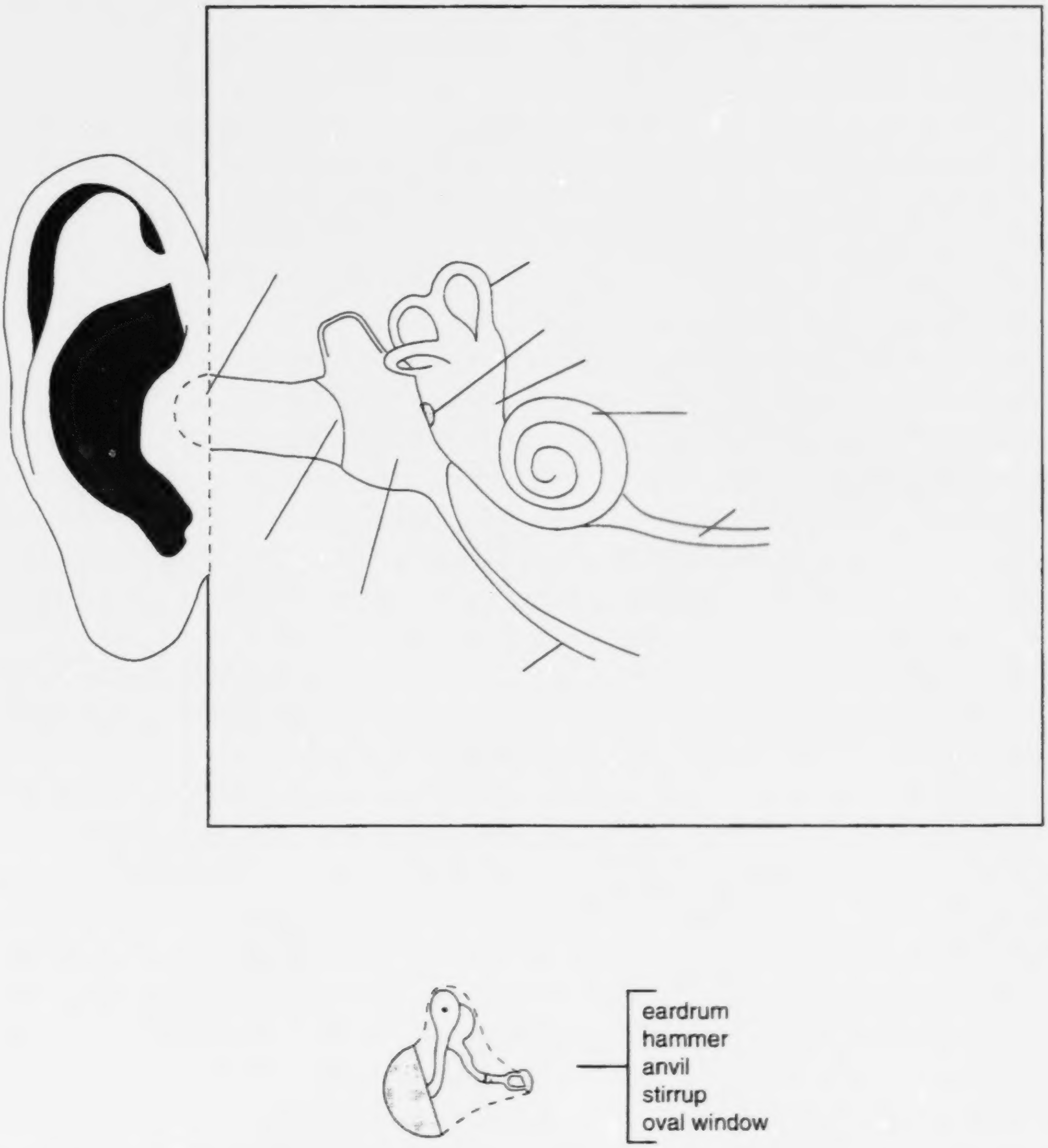
eardrum
hammer
anvil
stirrup
oval window

Figure SP 5.3.20B Working model of the ear

DASH

Name________________________

Date_________________________

STUDENT PAGE 5.3.1 PET CARE

Describe what must be done to care for your pet animal.

DASH

Name______________________

Date______________________

STUDENT PAGE 5.3.2 BIRD FEEDER

1. State your research question.

2. Describe how you intend to carry out the investigation.

3. Describe the data that you will be collecting.

4. Record your data on additional pages.

5. List any conclusions you can draw from your data.

DASH

Name________________________

Date________________________

STUDENT PAGE 5.3.3 BIRDS I KNOW

1. Give the local or scientific name of your bird and any special name you might have given it.

2. Describe the physical appearance of the bird you selected. Make a drawing of your bird and include photos if you take them.

Name________________________

3. Describe the bird's habitat or where it prefers to live.

4. What are your bird's nesting practices? Where does it nest? What kind of nest does it make? How does it care for its young?

5. What foods does your bird like to eat?

6. How does your bird interact with other birds and other kinds of animals?

SP 5.3.3–3

Name________________________

7. List your bird's predatory enemies, if any.

8. Do birds like yours have any economic value? Explain your answer.

9. Is your bird on the list of endangered birds? If so, how many of its species are left?

10. Tell about the special characteristics of your bird.

DASH

Name________________________

Date________________________

STUDENT PAGE 5.3.4 CELLS

1. Draw a small section of onion tissue showing the cells you observed.

2. Describe the cells you have observed.

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3. Describe how the onion cell compared with the cells in a root tip.

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4. Draw and label other kinds of cells you have observed.

DASH

Name______________________

Date______________________

STUDENT PAGE 5.3.5 CELL QUIZ

Indicate whether you think the following questions are true or false.

1.	Scientists who study cells are called *cytologists.* True False
2.	Cells are living things. True False
3.	Some animals are single-celled. True False
4.	Some plants are single-celled. True False
5.	Almost all single-celled plants and animals require a microscope to be seen. True False
6.	The animals and plants we normally see are made of many cells. True False
7.	All cells are not the same size. True False

Name ______________________

8.	Cells can be the size of golf balls. True False
9.	Cells can be so small that it takes 2,000 laid end to end to make a millimeter. True False
10.	Nerve cells that connect our brain with our muscles may have connecting fibers over a meter long. True False
11.	Elephants have nerve cells over 3 meters long. True False
12.	Cells are filled with a jelly-like material called *cytoplasm.* True False
13.	The cell's operation is directed by chemical information in it. True False
14.	Different cells in our body do different things. They have different functions. True False
15.	Groups of cells all doing the same thing are called *tissues.* True False

Name ____________________

16.	All our body cells must get nutrients from digested food. True False
17.	All the cells of our body produce waste. True False
18.	All the cells of our body must have oxygen. True False
19.	Most of the cells of our body can reproduce themselves. True False
20.	In most many-celled organisms a new individual starts with the joining of two cells. True False
21.	An egg is a single cell. True False
22.	Eggs are produced by females. True False
23.	Normally eggs are fertilized by sperm before they can develop into new organisms. True False
24.	Males produce sperm. True False

Name ______________________

25.	A human egg and sperm each carry half the chemical information needed to start the development of a baby. True False
26.	Human eggs are round and about 0.25 mm in diameter. True False
27.	Human sperm are spear-shaped and are about 0.05 mm long. True False
28.	A baby develops from two sex cells that multiply to around one and a half trillion (1,500,000,000,000) cells in nine months. True False
29.	An adult human of average size is made up of about 27 trillion cells (27,000,000,000,000). True False
30.	Every day our body throws out 30 million old cells and makes millions of new ones. True False

DASH

Name________________________

Date_________________________

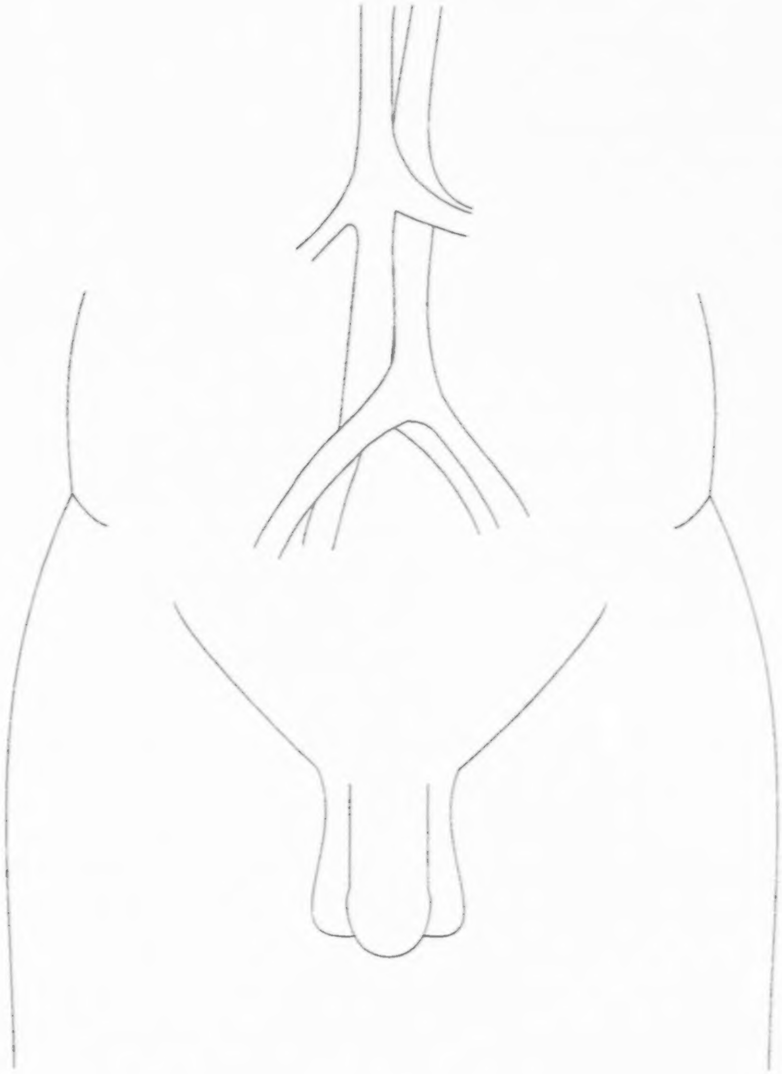
STUDENT PAGE 5.3.6A MALE UROGENITAL SYSTEM

1. Draw urogenital organs on the outline of the lower body of a male. Show how you think that the organs might be connected. Label the organs. Use Figure SP 5.3.6A.

2. Correct your drawing of the urogenital organs and their connections in the light of your reading of Student Page 5.3.6B BACKGROUND: THE UROGENITAL SYSTEM OF MALES.

3. Label the side-view diagram of the male urogenital system shown in Figure SP 5.3.6B.

Name ______________________



kidneys

bladder

prostate
gland
urethra

testicles

Figure SP 5.3.6A Front view of male urogenital system

DASH

Name________________________

Date________________________

STUDENT PAGE 5.3.6B
BACKGROUND: THE UROGENITAL SYSTEM OF MALES

Mammals are warm-blooded animals that have fur and nurse their young. Cats, dogs, cows, rabbits, guinea pigs, mice, chimpanzees, gorillas, and we humans are all mammals. With little modification, the organ systems of one mammal are very similar to those of another. When we learn about the anatomy of another mammal, we can fairly well apply that information to ourselves.

1. What is the urogenital system?

The urogenital system is really two systems that work together. These are the urinary system and the reproductive system. *Genitals* are the reproductive organs.

2. Why are the two systems considered together?

In males the products from both the reproductive system and the urinary system exit from the body through the same organ, the penis. In other words, both urine and sex cells (sperm) leave the body through the penis.

3. What organs make up the urinary system of males?

The organs of the urinary system are the kidneys, the bladder, and the penis.

4. Where are the kidneys located?

Two kidneys are located close to the spine in the lower half of the torso.

5. What is the function of the kidneys?

The kidneys remove water and waste, particularly urea from the blood. Urea is produced in the liver from the breakdown products of protein. The mixture of waste and water is called *urine*.

Name ____________________

6. What is the path of the blood into and out of the kidneys?

The blood comes to the kidneys directly from the heart through the main body artery called the *aorta*. It leaves the kidneys through the main body vein, the *vena cava,* which takes it directly to the heart. These very large blood vessels lie right against the protective spine.

7. Where does the urine go from the kidneys?

The urine travels to the bladder from each of the kidneys through a tube called the *ureter*.

8. What is the bladder and its function?

The *bladder* is a balloon-like sac that collects and stores urine until it can be gotten rid of. The bladder of an adult human holds about 500 mL of urine. When the bladder is about half full, we can begin to feel the need to urinate. Normally the adult body produces about 1500 mL of urine a day.

9. Where does the urine go after leaving the bladder?

Urine leaves the bladder through a tube called the *urethra*. In the male the urethra passes through a gland called the prostate then through the penis.

10. How do we control the flow of urine from the bladder?

There are a series of muscles that we can voluntarily close and open. Human males usually gain daytime control over these muscles by the age of three years. Night control is often gained at the same time, though some individuals may not gain night control until their teen years.

11. What organs make up the male reproductive system?

Male reproductive organs include the testes, the epididymis, the prostate gland, and the penis.

12. What are the functions of the testicles?

The *testicles* are the organs in which the sperm develop. They are also the organs where chemicals called sex hormones are manufactured. In humans these sex hormones stimulate the growth of a beard and body hair and thicken vocal cords, lowering the pitch of the voice.

Name ______________________

13. Where do sperm go after they leave the testicles?

Once sperm are released, they are moved into a storage tube called the *epididymis.*

14. How do sperm get to the urethra?

Sperm travels in a sperm duct or tube from the epididymis to the point where the prostate gland surrounds the urethra. There the duct empties the sperm into the urethra.

15. What is semen?

Semen is the fluid that carries the sperm out of the penis.

16. How is semen made in the body?

Fluids from the prostate and other glands are added to the fluid bathing the sperm. Together these fluids and the sperm are called *semen.* It is semen that leaves the body carrying the sperm.

17. How long do males produce sperm?

Human males usually start to produce sperm between the ages of 13 and 15 and frequently produce them all their lives.

18. How does the semen leave the body?

Semen leaves the body in a muscular contraction called an *ejaculation.* It is forced out of the penis as a jet of fluid.

Name ______________________

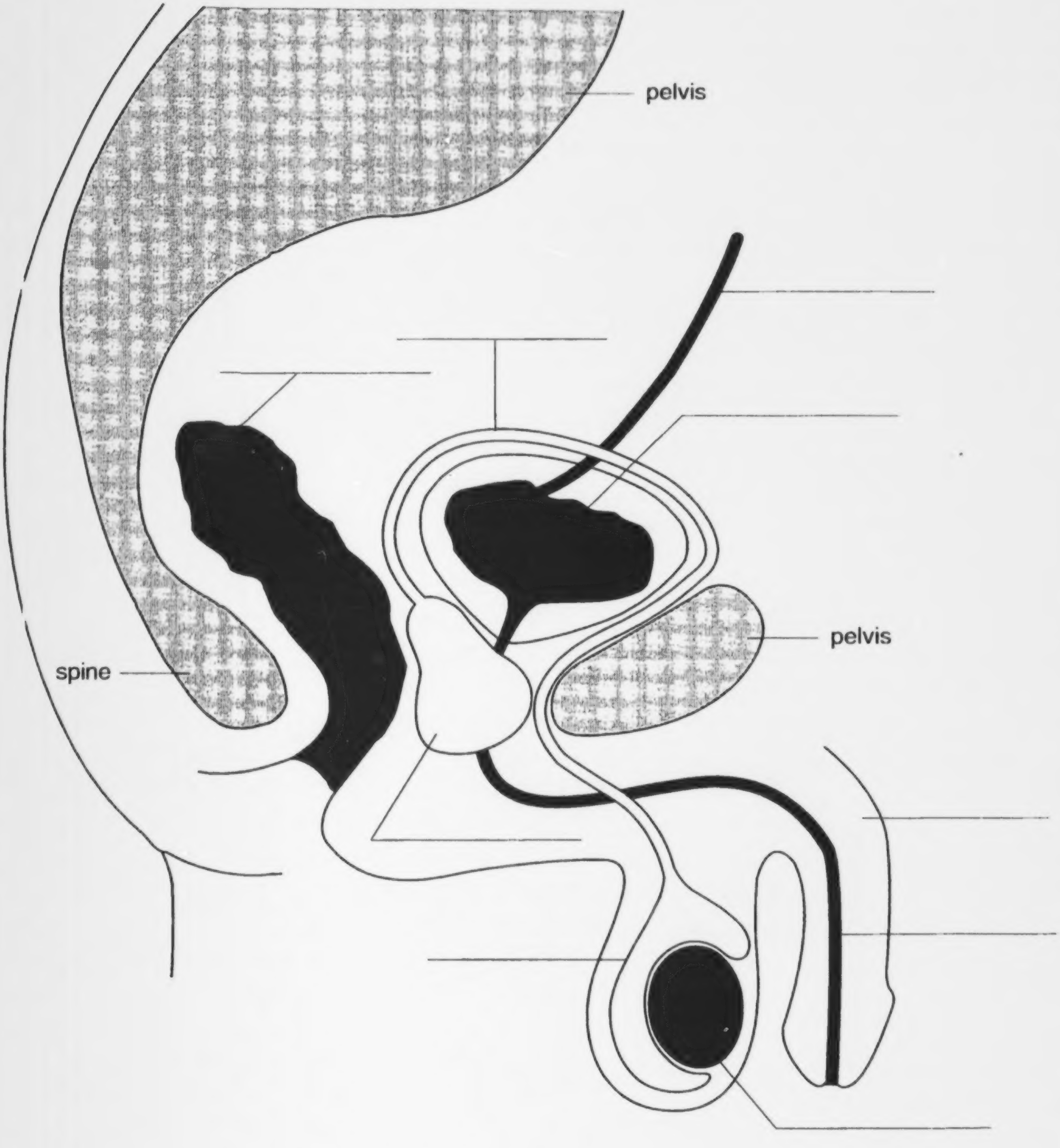

pelvis
pelvis
spine

Figure SP 5.3.6B Side view of male urogenital system

DASH

Name____________________________

Date_____________________________

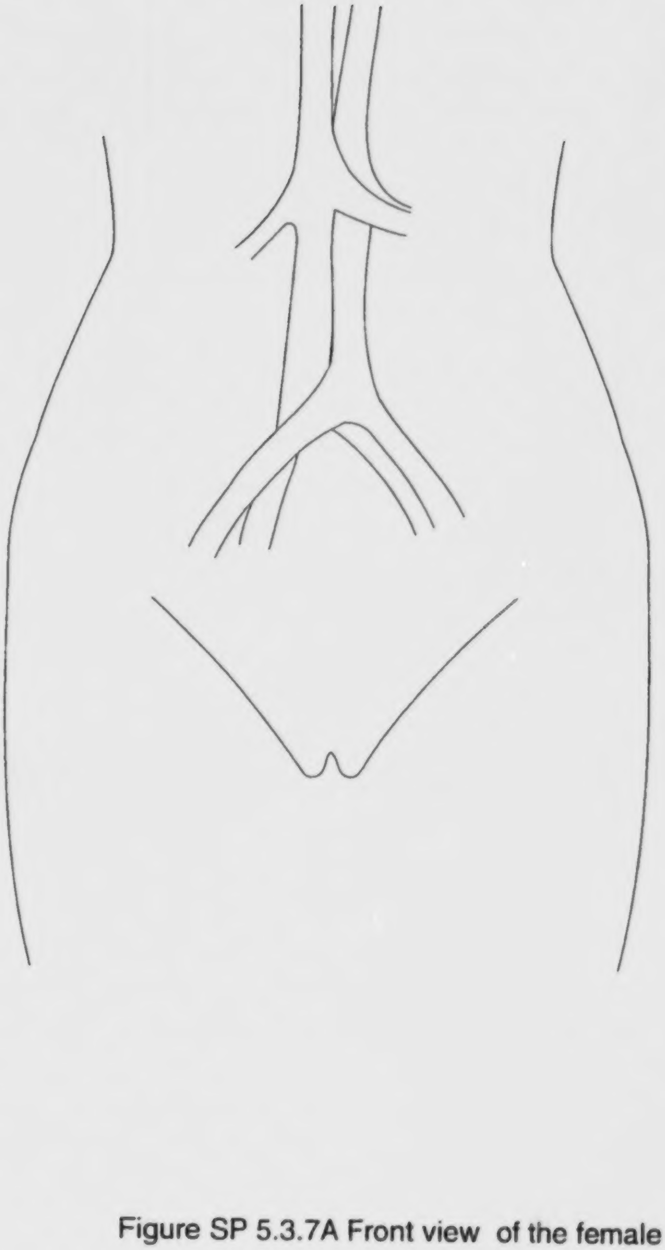
STUDENT PAGE 5.3.7A FEMALE UROGENITAL SYSTEM

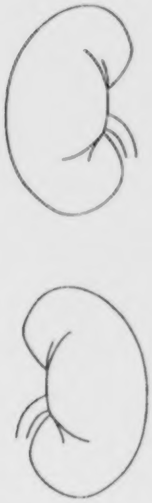
1. Draw urogenital organs on the outline of the lower body of a female. Show how you think that the organs might be connected. Label the organs. Use Figure SP 5.3.7A.

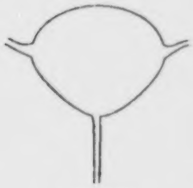
2. Correct your drawing of the urogenital organs and their connections after reading Student Page 5.3.7B BACKGROUND: THE UROGENITAL SYSTEM OF A FEMALE.

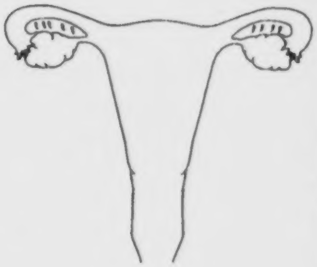
3. Label the side view of the female urogenital system shown in Figure SP 5.3.7B.

Name ____________________









ovaries
uterus
vagina

Figure SP 5.3.7A Front view of the female urogenital system

Name________________________

Date________________________

STUDENT PAGE 5.3.7B
BACKGROUND: THE UROGENITAL SYSTEM OF FEMALES

Most of the organs in the bodies of human males and females are the same. An exception is found in the reproductive organs, which are different in shape and function.

1. What are the differences in the male and female urogenital systems?

In the human female the urinary system and the reproductive systems are completely separate. Each system has a separate opening. The only thing the two systems share is the vulva. In the male urogenital system the two systems are joined together by the urethra.

2. What is the vulva?

The *vulva* is the visible external fold of tissue covering the openings to both the urinary and reproductive systems of the female.

3. What are the female urinary system organs?

Urinary organs of the female are the kidneys and the bladder. As in the male, the tubes connecting the bladder and kidneys are the *ureters,* and the tube emptying the bladder is the *urethra.*

4. What is the function of the urinary system in the female?

As in the male, the function of the female's urinary system is to remove water and waste from the blood and the product is the liquid called *urine.* Because it carries waste, urine can be used by doctors to tell whether the body is working properly. If the wastes are not normal, it can be assumed that something is wrong in the body.

5. What are the differences in the male and female urinary organs and tubes?

Organs and tubes are the same except for one thing—the urethra of the female empties at the vulva while the urethra of the male empties through the penis.

Name ______________________

6. What organs make up the female reproductive system?

Female reproductive organs include the ovaries, oviducts, the uterus, and the vagina.

7. What are the functions of the ovaries?

The *ovaries* are the organs in which eggs develop. Ovaries are also the place where chemicals called *sex hormones* are manufactured. In human females these sex hormones stimulate the growth of body hair, development of the breasts, and a change in the voice.

8. How many ovaries does the female have?

There are two ovaries, one on the right side of the body and one on the left.

9. How many eggs does the female produce?

At birth the human female baby has 100,000 or more immature eggs in her ovaries. Of all of these eggs, only some 400 will be used in a lifetime. In humans usually one egg is released each month.

10. What is the meant by ovulation?

Ovulation involves the release of an egg by the ovary. In humans this process occurs about once every 28 days.

11. How long does the female produce eggs?

The human female usually produces eggs starting from age 12 to 15 and stops ovulation between 45 and 50.

12. Where does an egg go after it leaves the ovary?

When an egg is mature, it is released and maneuvered into an oviduct.

13. Where does the oviduct take the egg?

The egg travels through an oviduct to the uterus. The oviduct is lined with cells that have tiny hairs called *cilia*. These cilia move in a wave-like motion, pushing the egg down the oviduct.

14. What is the function of the uterus?

The *uterus* is the organ in which a fertilized egg develops into a baby. In humans the uterus is a triangular pouch. The oviducts open into the uterus at the upper corners.

Name ______________________

15. What happens to an egg if it is not fertilized?

If the egg is not fertilized, it disintegrates and passes out of the body during menstruation. If it is fertilized, it can attach itself to the wall of the uterus and develop into a baby.

16. What is the function of the vagina?

The *vagina* is the place where semen is delivered by the male penis.

Name ______________________

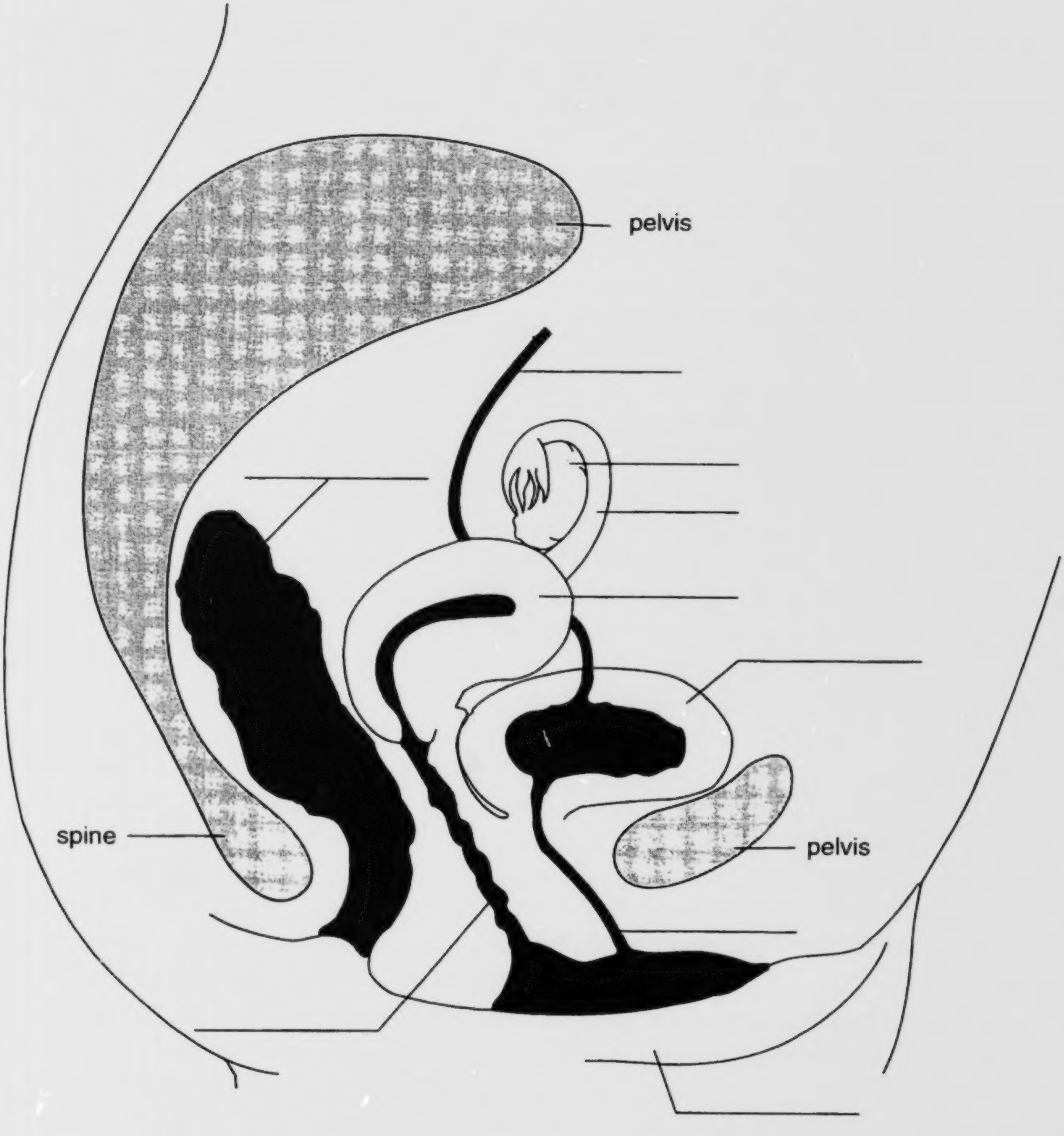

pelvis
spine
pelvis

Figure SP 5.3.7B Side view of the female urogenital system

DASH

Name________________________

Date________________________

STUDENT PAGE 5.3.8A BACKGROUND: OVULATION CYCLE

Female mammals have only certain times during the year when they can become pregnant. Different mammals have different ovulation cycles

1. What is an ovulation cycle?

In humans an *ovulation cycle* is the series of events that start with the beginning of the ripening of an egg in the ovary. Some 28 to 29 days later it ends with the start of the next ripening of an egg.

2. Where does the ripening of the egg occur?

Ripening occurs in the ovaries that have a huge stock of immature eggs. At any time different eggs will be in different stages of development. Eggs develop in an *ovarian follicle.*

3. What is an ovarian follicle like?

An ovarian follicle looks like a liquid-filled balloon with an egg attached to its wall. Follicles grow very slowly in the ovary. When it is an egg's turn to ripen, its follicle expands very quickly and pushes through the surface of the ovary like a blister. On the 14th day of the cycle the follicle bursts open, releasing the egg.

4. How large are the follicle and the egg?

When ripe and ready to burst the follicle is about 5 mm in diameter, and the egg is about 0.25 mm in diameter. The follicle is about the size of a pencil eraser, and the egg is about the size of the tip of a sharpened pencil.

5. What happens to the follicle once it has broken open?

The follicle heals, forming a scar called the *corpus luteum.* In Latin *corpus luteum* means yellow body.

Name____________________

6. How long does the corpus luteum remain on the ovary?

The life of the corpus luteum depends on what happens to the egg. If the egg is fertilized and develops into a baby, the corpus luteum lasts till the baby is delivered. If the egg is not fertilized, it disappears at the end of the ovulation cycle.

7. What is the role of the corpus luteum?

It releases *hormones* (chemicals) that help in the development of the egg into a baby.

8. What else occurs as the egg ripens?

In humans ripening of an egg accelerates at the same time as the beginning of menstrual flow. Another name for ovulation cycle is *menstrual cycle.*

9. What is menstrual flow?

Menstrual flow is a passage of blood and tissue out of the body through the vagina. Menstrual flow results from the breakdown of blood vessels in the endometrium.

10. Why do these blood vessels break down?

Every time a new egg gets ready to ripen, the uterus prepares a new bed of spongy tissue that is full of blood vessels to receive it. This bed is called the *endometrium*. It is like the soil of a garden. The fertilized egg will rest on this bed and grow into it. The endometrium will supply the nutrients necessary for the growth of the egg into a baby. If the egg is not fertilized, the old bed is carried away in the menstrual flow.

11. How long does the menstruation last?

The old bed of blood vessels and spongy tissues is usually removed from the system in 1 to 8 days. This time of blood flow is called the *period.* When the flow stops, the building of a new bed or endometrium begins immediately. The average loss of blood is about 60 mL.

Name________________________________

12. What happens to the egg once it is released?

Once released from the follicle, the egg moves into the oviduct. Here it is pushed along toward the uterus by tiny hairs called *cilia.*

13. Where would the egg normally be fertilized?

Normally the egg is fertilized when it is in the upper part of the oviduct.

14. What happens to the egg once it gets to the uterus?

If it is not fertilized, the egg will die within about 24 hours after it is released. If it is fertilized, the developing egg moves into the uterus where it can plant itself in the blood-vessel bed of the uterus. This planting occurs 8–10 days after fertilization.

15. What happens to the blood vessel bed in the uterus once the fertilized egg is planted in it?

The egg develops into an embryo that sends out its own network of blood vessels. These vessels grow so closely to the blood-vessel bed in the uterus that blood fluids can pass between them. In this way the mother nourishes the baby. The blood vessel network of the growing baby and the mother is called a *placenta.*

16. Does the ovulation cycle always follow the same time table?

No. There are many things that can make this ovulation cycle irregular. These include emotional upsets, illness, and even athletic participation.

17. When can fertilization occur?

Fertilization can occur in the 24-hour period following the release of the egg. Sperm remain alive and able to fertilize the egg for 48 hours or 2 days in the fluids of the oviduct and uterus.

18. Why do the sperm and eggs die?

Both the sperm and egg have a limited amount of nutrient material and cannot get full access to the nutrients in the uterus unless they join in fertilization.

Name____________________________________

19. What is the sequence of events in the ovulation cycle?

- A follicle on the ovary rapidly enlarges from the beginning of the cycle until it breaks open or ruptures.
- This follicle usually ruptures between Day 12 or 15 of the cycle, releasing an egg. **It is at this time that fertilization normally occurs.**
- After release the egg starts its 8-to-10 day travel down the oviduct to the uterus.
- The egg degenerates if it is not fertilized. **If it is fertilized, the egg starts growing when it is implanted in the endometrium of the uterus.**
- On average, after 28 days the old cycle ends. The length of the cycle is variable, and it is not unusual for it to be as short as 24 days or as long as 35.
- Menstruation begins Day 1 of the new cycle and lasts from 1–8 days, on average 4 days.
- In menstruation the old endometrium is carried away in a flow of blood.
- New endometrium tissue builds from the end of menstruation to the last days of the cycle.
- The corpus luteum starts forming after rupture of the follicle and continues to produce hormones throughout pregnancy. If there is no fertilization, the corpus luteum stops growing in the last days of the cycle. Thereafter it degenerates and is gone by Day 14 of the next cycle.

DASH

Name____________________________

Date____________________________

STUDENT PAGE 5.3.8B OVULATION CYCLE

1. **Use the terms below to label the life–sized diagram of the female reproductive organs shown in Figure SP 5.3.8B(1). This view is a cross section showing the interior of the organs.**

oviduct
ovary
uterus
vagina

2. **Use the terms below to label the enlarged diagram of the cross section of the ovary shown in Figure SP 5.3.8B(2).**

immature follicle
maturing follicles
rupturing follicles
corpus luteum
ovum or egg

3. **Identify the events on the ovulation cycle shown in Figures SP 5.2.8B(3–4). Connect the figures so that they make a continuous time line for an average 28-day ovulation cycle.**

On the diagrams of the uterus follow the travels of the egg by showing where it is each day during the 28-day cycle. Mark with a small *(x)*.

On the diagrams of the entire ovary follow the

- Development of the ovarian follicle by circling it in *blue*
- Development of the new corpus luteum by circling it in *yellow*
- Breakdown of the old corpus luteum by circling it in *purple*

On the diagram of the breakdown and buildup of the endometrium

- Underline the period of breakdown of the endometrium or menstruation in *brown*
- Underline the interval of buildup of the endometrium in *red*

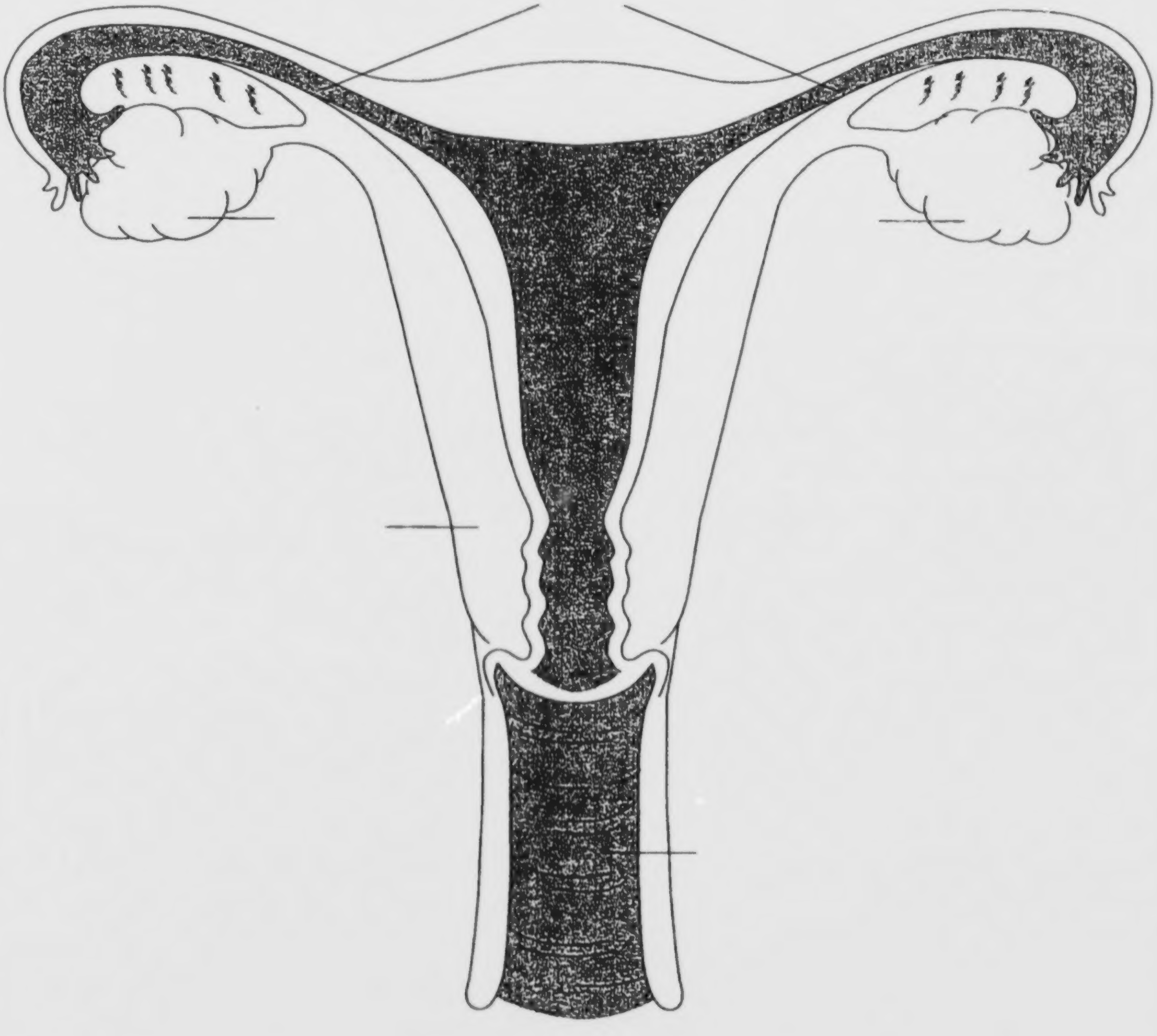


Figure SP 5.3.8B(1) Cross section of female reproductive organs

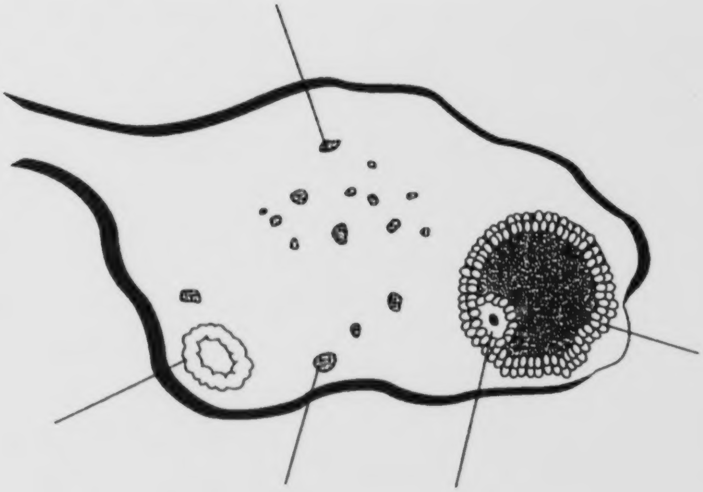


Figure SP 5.3.8B(2) Enlarged cross section of the ovary

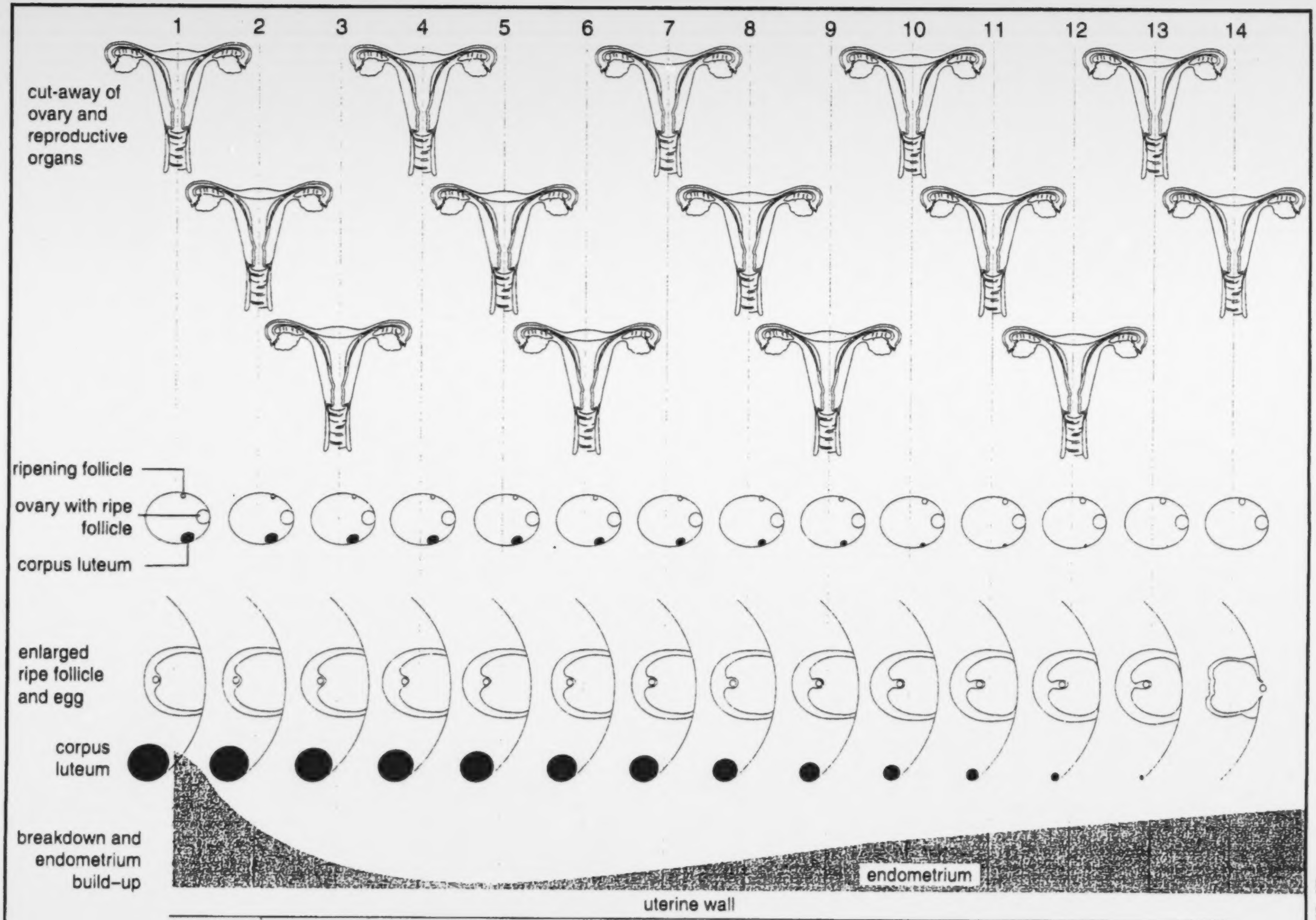

1
2
3
4
5
6
7
8
9
10
11
12
13
14
cut-away of ovary and reproductive organs
ripening follicle
ovary with ripe follicle
corpus luteum
enlarged ripe follicle and egg
corpus luteum
breakdown and endometrium build–up
endometrium
uterine wall

Figure SP 5.3.8B(3) Average ovulation cycle days 1 to 14

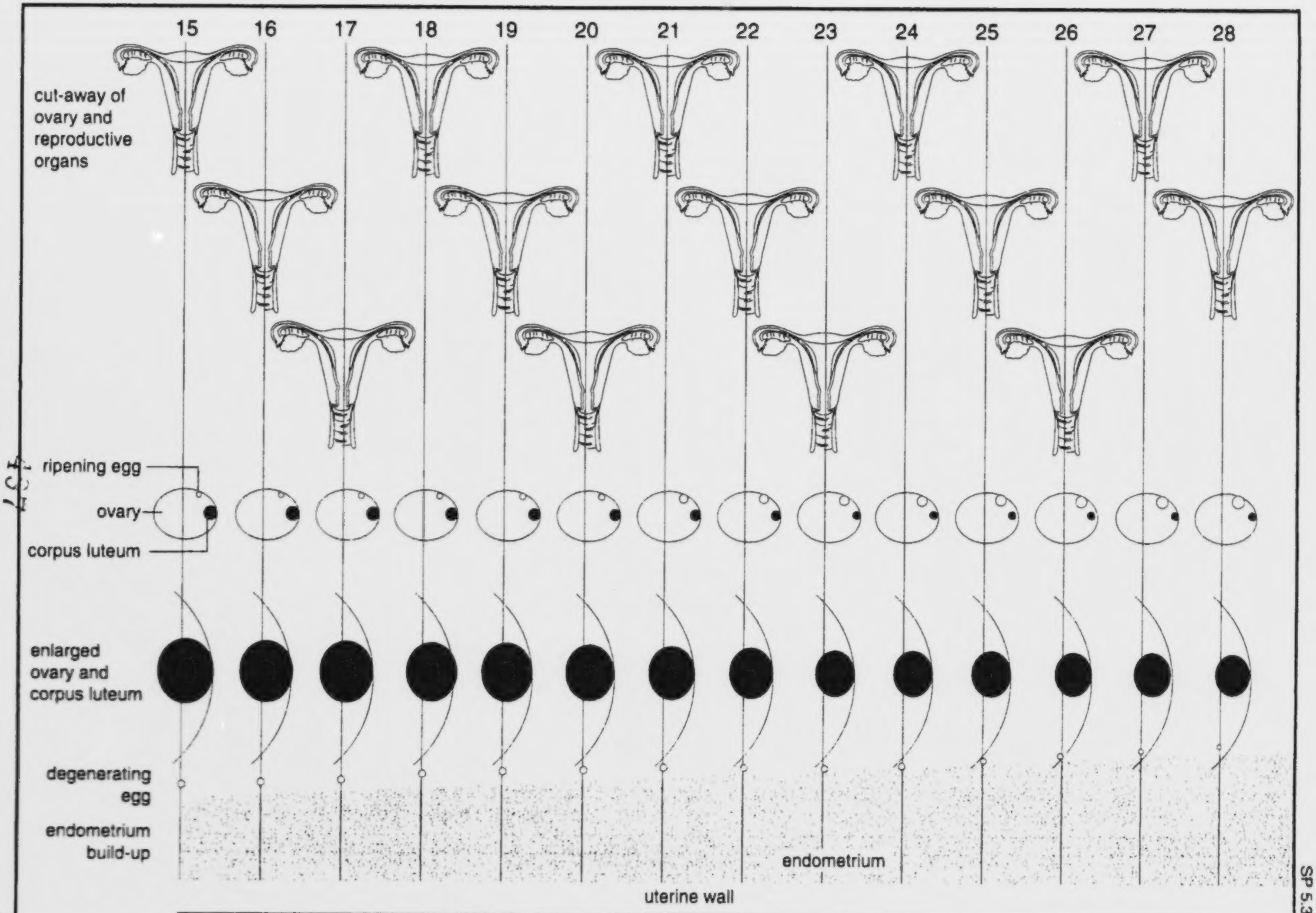

15
16
17
18
19
20
21
22
23
24
25
26
27
28
cut-away of ovary and reproductive organs
ripening egg
ovary
corpus luteum
enlarged ovary and corpus luteum
degenerating egg
endometrium build-up
endometrium
uterine wall

Figure SP 5.3.8B(4) Average ovulation cycle days 15 to 28

Name______________________________

Date______________________________

STUDENT PAGE 5.3.9A
BACKGROUND: OVULATION, PREGNANCY, AND DELIVERY

1. What is pregnancy?

Pregnancy is the condition that exists when a mother is carrying a fertilized egg, an embryo, or a fetus in her body.

2. When does pregnancy start?

Pregnancy starts at the point when an egg is fertilized by a sperm. In humans this usually occurs 12 to 15 days after the start of the menstruation.

3. Where does fertilization occur in the body?

Fertilization of the egg usually occurs in the upper end of the oviduct just after the egg is released by the ovary, the organ where eggs develop. The oviducts are also called the *fallopian tubes.*

4. What happens after fertilization?

The egg immediately starts to divide into 2 cells, then into 4, then 8, 16, 32, and so forth. At this point an *embryo* has started to form.

5. Where does the developing embryo go next?

For 8 to 10 day it travels down the oviduct toward the uterus. It is constantly pushed along by tiny moving *cilia,* or hairs.

6. Once the embryo reaches the uterus what does it do?

It plants itself in the rich blood-vessel bed of the endometrium and begins to grow its own blood-vessel system among the vessels of the endometrium. Together, the baby's and mother's systems of blood vessels become the placenta.

Name____________________________

7. What are the results of the embryo's developing its own blood-vessel system?

Neither the embryo nor the fetus ever becomes a part of the mother's body. They are like a ship tied to a dock, getting all its supplies from the "motherland." The mother supplies the developing baby nutrients through fluids that pass out of her blood vessels and enter the vessels of the developing baby. This protects the baby from the passage of infectious bacteria and some chemicals in the mother's blood that might harm the baby.

8. How long does the developing baby stay in the uterus?

This a variable period. A normal birth takes place some time near the end of the ninth month after pregnancy begins. A premature child may be born and saved after about the 28th week of pregnancy. Often a baby may arrive several weeks after the ninth month.

9. What happens in the ovaries during the period of the pregnancy?

The ovaries stop producing eggs and the corpus luteum grows into a gland that helps regulate the pregnancy.

10. How does the developing baby get its nutrients from the placenta?

In the embryo stage an umbilical cord is formed. This cord has both venous and arterial vessels carrying blood to the placenta and back into the body.

11. What happens to the umbilical cord at birth?

The umbilical cord is cut and tied off so that the newborn becomes completely independent of the mother.

12. How does the baby leave the mother?

Normally when the fetus is fully developed, the mother will go into a condition called *labor* and will push the baby out of the uterus through the vagina into the outside world. The muscles used are those of the abdomen, the diaphragm, and the uterus itself. This is called *natural delivery*.

13. What happens to the placenta?

It is expelled from the uterus right after the baby is born.

Name______________________________

14. What is a cesarean section?

A *cesarean section* is a surgical delivery of a baby. The lower part of the abdomen is cut open and the baby is removed through a second cut in the wall of the uterus. Cesarean delivery is done when the opening in the pelvis is too small for the baby to pass, when there are complications in the growth of the placenta, or when problems are anticipated in natural delivery.

15. What happens to the uterus after delivery of the baby?

Usually the uterus has completely healed within a month of delivery.

DASH

Name____________________

Date____________________

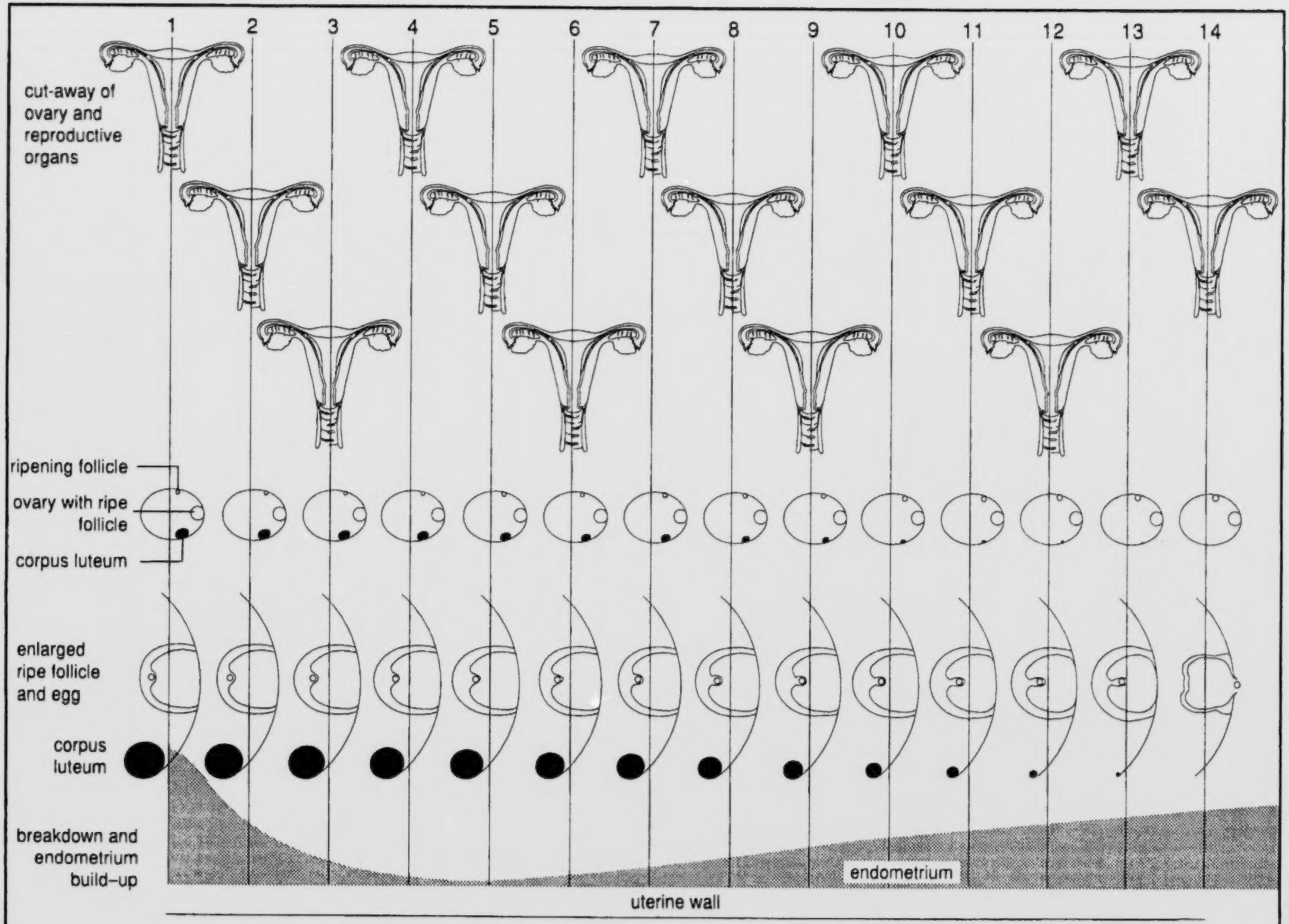
STUDENT PAGE 5.3.9B OVULATION AND PREGNANCY

Identify the events of ovulation, fertilization, and the first 14 days of pregnancy shown in Figures SP 5.3.9B(1–2). Connect the figures so that they make a continuous time line.

1. **On the diagrams of the uterus follow the travels of the fertilized egg and embryo by showing where they are each day after ovulation. Mark the progress with an *(o).***

2. **On the diagrams of the entire ovary follow the**
    - **Development of the ovarian follicle by circling it in *blue***
    - **Development of the new corpus luteum by circling it in *yellow***
    - **Break down of the old corpus luteum by circling it in *purple***

3. **On the diagram of the breakdown and buildup of the endometrium**
    - **Underline the period of breakdown of the endometrium or menstruation in *brown***
    - **Underline the buildup of the endometrium in *red***
    - **Underline the time of growth of the embryo in the wall of the uterus in *orange***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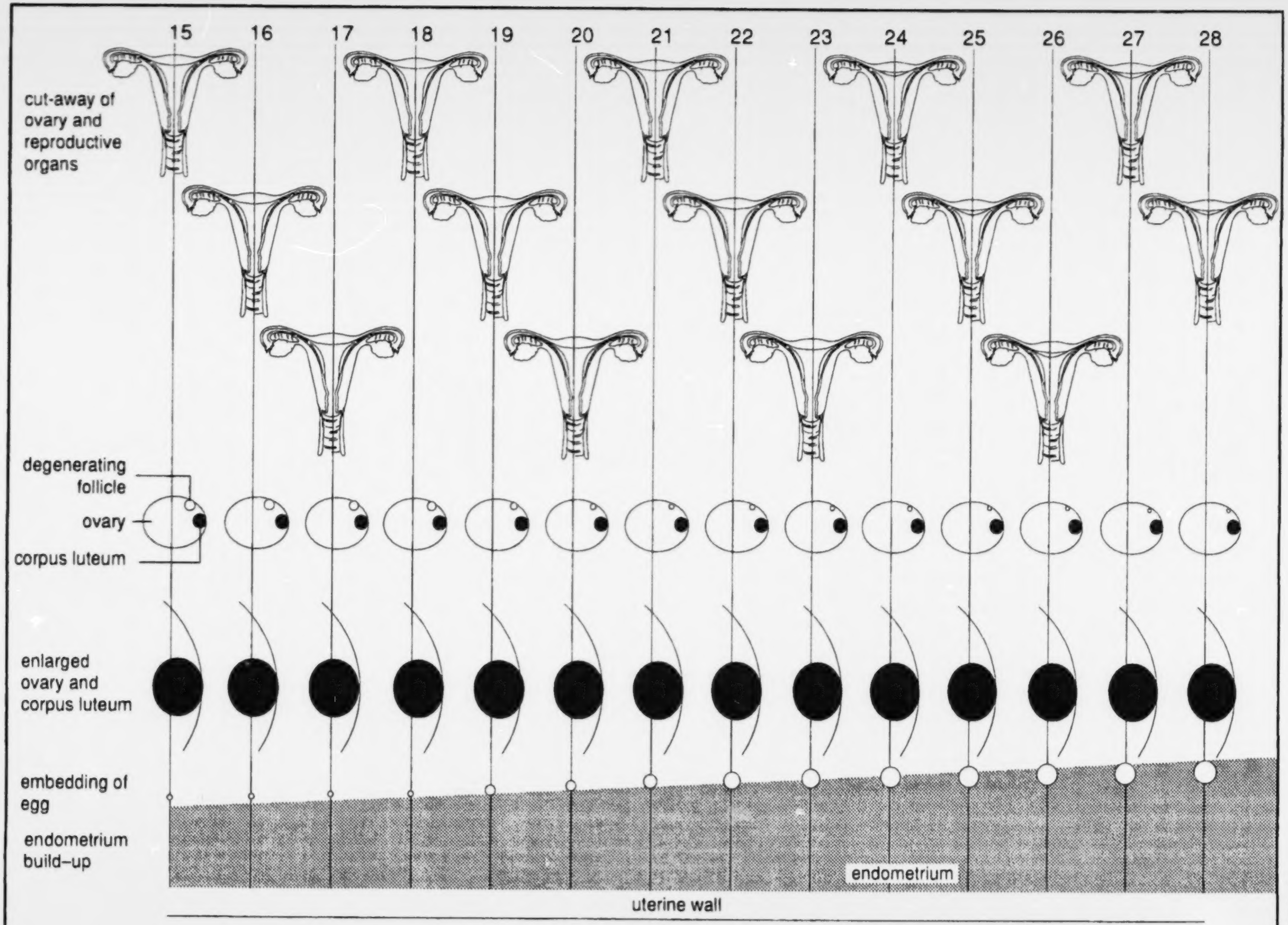
14
cut-away of ovary and reproductive organs
ripening follicle
ovary with ripe follicle
corpus luteum
enlarged ripe follicle and egg
corpus luteum
breakdown and endometrium build–up
endometrium
uterine wall

Figure SP 5.3.9B(1) Average ovulation cycle days 1 to 14


15
16
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21
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24
25
26
27
28
cut-away of ovary and reproductive organs
degenerating follicle
ovary
corpus luteum
enlarged ovary and corpus luteum
embedding of egg
endometrium build–up
endometrium
uterine wall

Figure SP 5.3.9B(2) Pregnancy days 15 on

Name__________________________

Date__________________________

STUDENT PAGE 5.3.10 EMBRYOLOGY

1. On a separate sheet of paper make a table to collect data on the age of the developing embryo or fetus and its length, mass, and volume. Leave space to record special developing structures. One gram of body mass is equal to 1 cubic centimeter or 1 milliliter.

2. Graph the relationship between the age and mass of the developing embryo or fetus from the 8th week.

Name ______________________________

3. **Interpret the data. Describe what happens to the mass of the embryo and the fetus over the period of the pregnancy.**

____

____

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4. **Graph the relationship between the age and length of the fetus from the 8th week.**

Name ______________________________

5. **Interpret the data. Describe what happens to the length of the embryo and the fetus over the period of the pregnancy.**

6. **Graph the relationship between the age and volume of the fetus from the 8th week. The *specific gravity* of the fetus is 1. One cubic centimeter of body tissue has the same mass as 1 cubic centimeter (1 milliliter) of water.**

Name ______________________________

7. Interpret the data. Describe what happens to the volume of the embryo and the fetus over the period of the pregnancy.

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Name______________________

Date______________________

DASH

STUDENT PAGE 5.3.11 BODY CHANGES

Predict how you will change between now and the sixth grade in regard to the following:

HEIGHT ______________________

WEIGHT ______________________

OTHER CHANGES:

____

____

____

____

____

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____

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Name______________________________

Date______________________________

DASH

STUDENT PAGE 5.3.12 BONES

1. Draw the bones of the following areas as you think they would look from the way that they feel. Put the number of bones you find of this kind in the parentheses next to the name of the bone group.

Skull including the jaw **Number of bones ( )**

Spine **Number of bones ( )**

Subtotal ( )

Name ______________________

Ribs Number of bones ( )

Shoulder bones Number of bones ( )

Pelvis Number of bones ( )

Arm Number of bones ( )

Subtotal ( )

Name ____________________

Leg **Number of bones ( )**

Hand and wrist **Number of bones ( )**

Foot **Number of bones ( )**

Subtotal ( )
Grand total ( )

2. Make a 360° protractor and describe how you made it.

____

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____

Name ______________________

3. Describe the ways the different bone-muscle groups move and record the amount of movement in degrees.

The skull

____

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____

The spine (vertebrae)

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____

____

The rib cage

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____

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____

The shoulder

____

____

____

____

The arm

____

____

____

____

Name ______________________

The leg

The pelvis

The foot

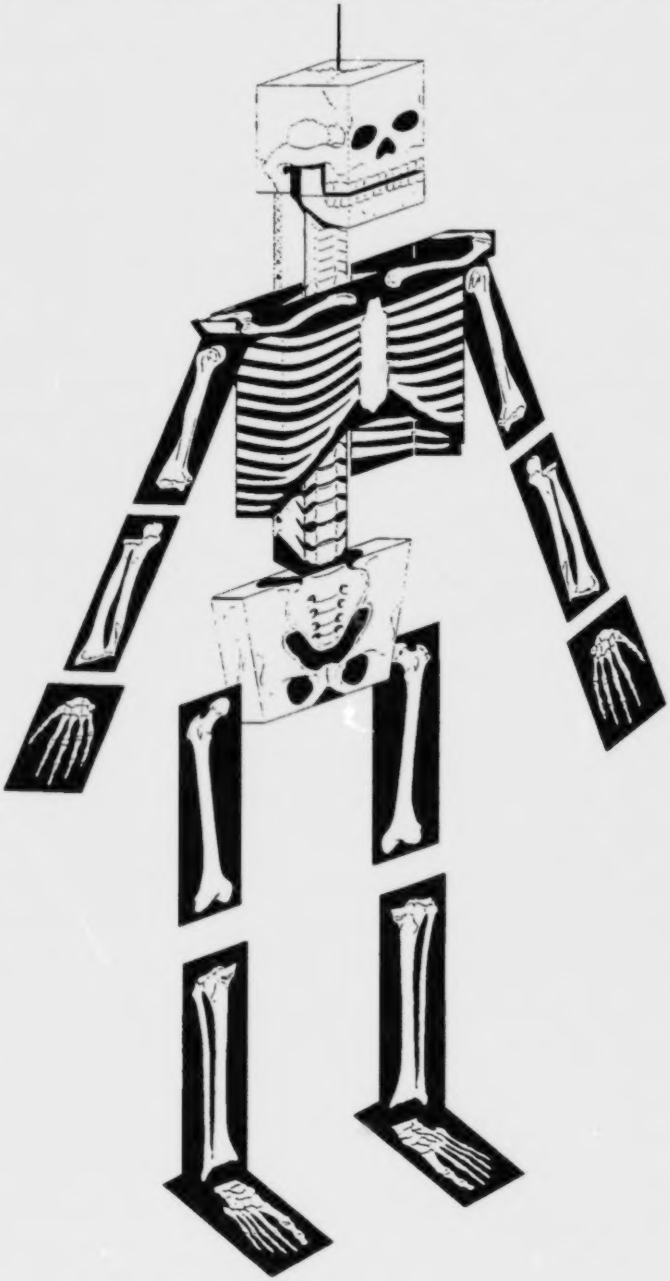
The hand and wrist

SP 5.3.13 SKELETAL SYSTEM

Name ______________________

Date ______________________

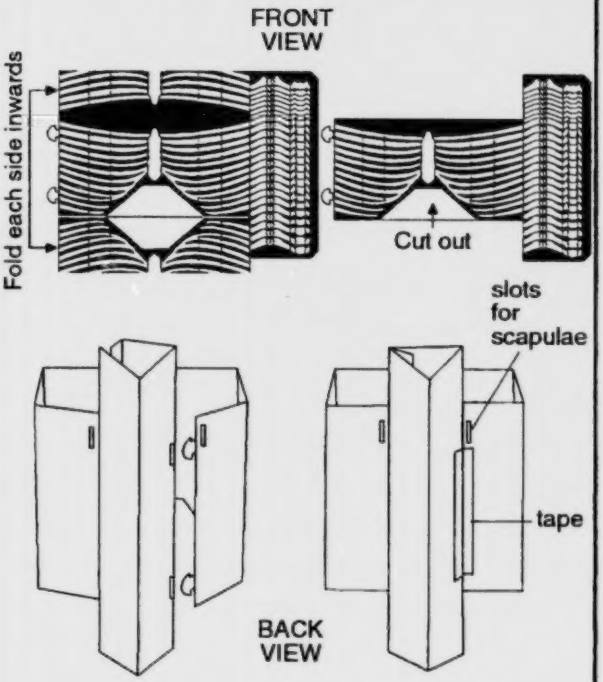
Cut out the pieces of the skeleton and assemble them using tape and string.



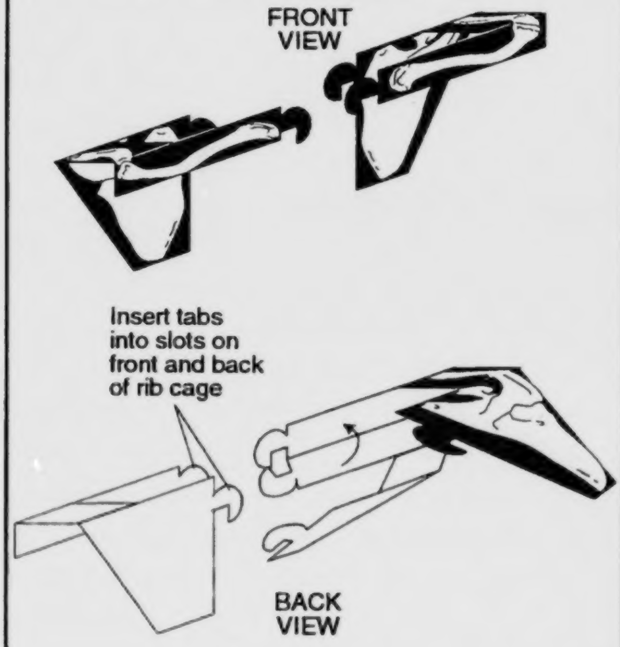
Assembled model of human skeleton

INSTRUCTIONS FOR ASSEMBLY OF SKELETON

FOLDING SPINE AND CHEST

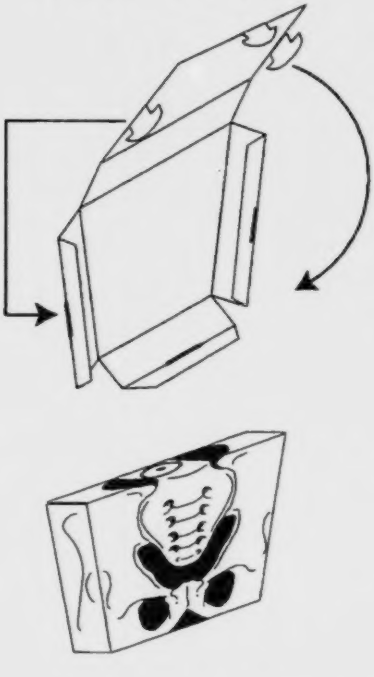

FRONT VIEW
Fold each side inwards
Cut out
slots for scapulae
tape
BACK VIEW

FOLDED CLAVICLES AND SCAPULAE


FRONT VIEW
BACK VIEW

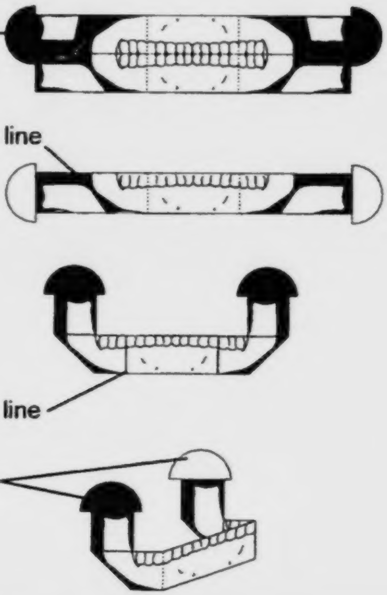
Insert tabs into slots on front and back of rib cage

FOLDED PELVIS



Insert tabs into slots

FOLDING JAW



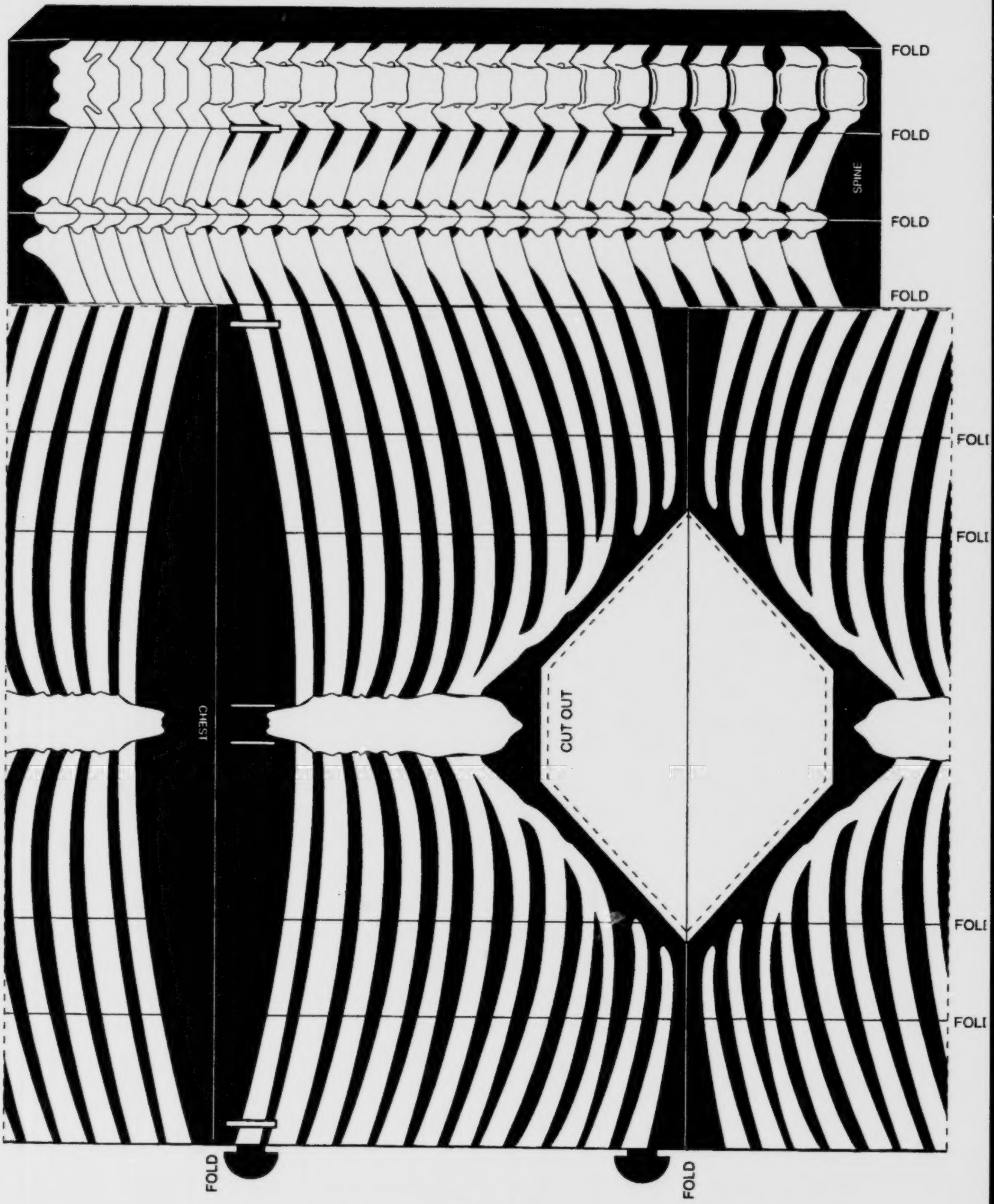
Fold back

Fold back on line

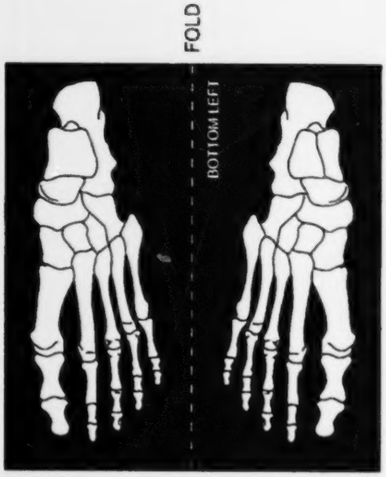
Fold back on line

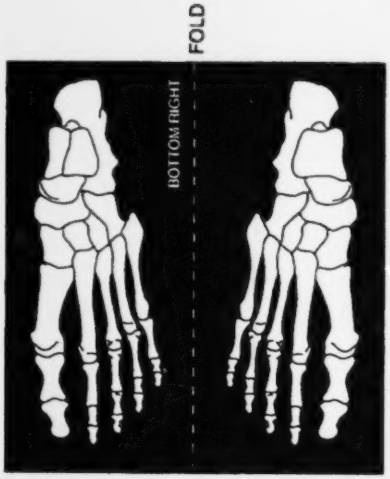
Insert tabs into slots on both sides of skull

SPINE AND CHEST


FOLD
FOLD
SPINE
FOLD
FOLD
FOLI
FOLI
CHEST
CUT OUT
FOLI
FOLI
FOLD
FOLD

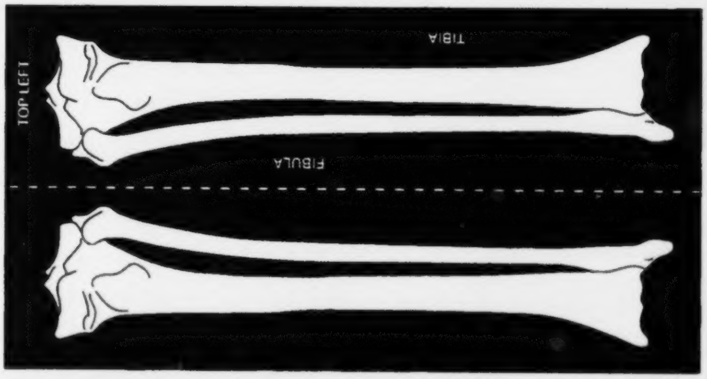
FEET

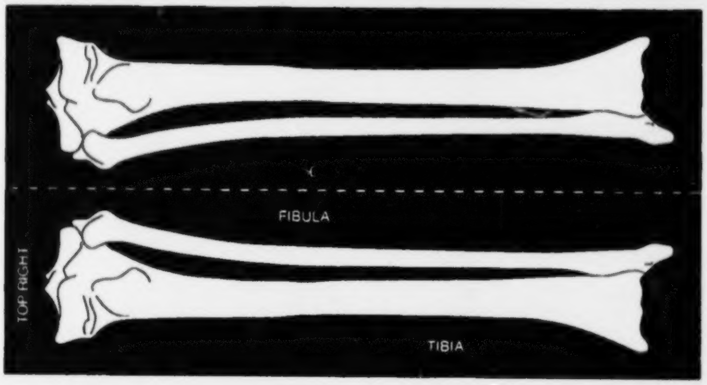

FOLD
BOTTOM LEFT


FOLD
BOTTOM RIGHT

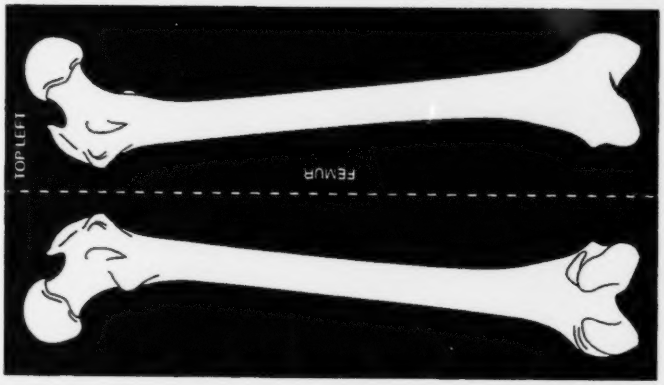
LEGS

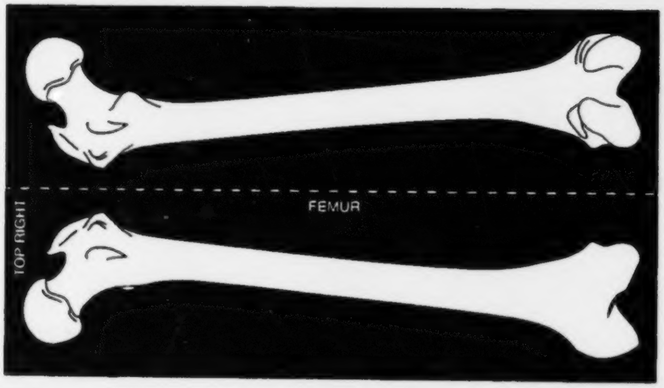
TIBIA AND FIBULA


TIBIA
TOP LEFT
FIBULA
FOLD

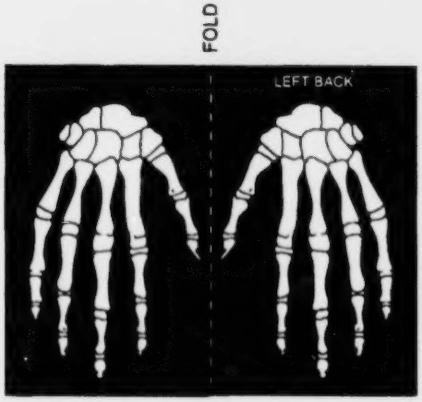

FOLD
FIBULA
TOP RIGHT
TIBIA

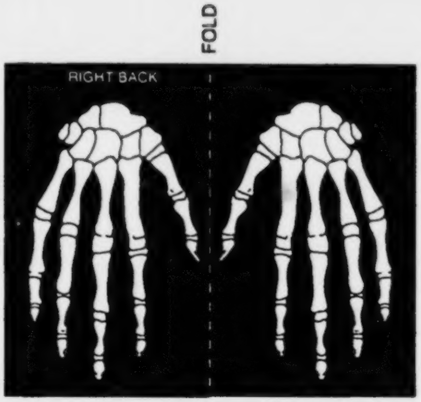
FEMUR


TOP LEFT
FEMUR
FOLD


FOLD
FEMUR
TOP RIGHT

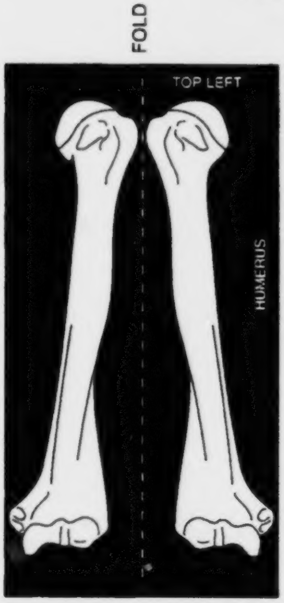
HANDS


FOLD
LEFT BACK


FOLD
RIGHT BACK

ARMS

HUMERUS


FOLD
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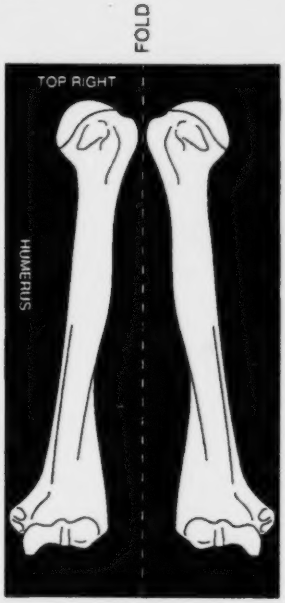
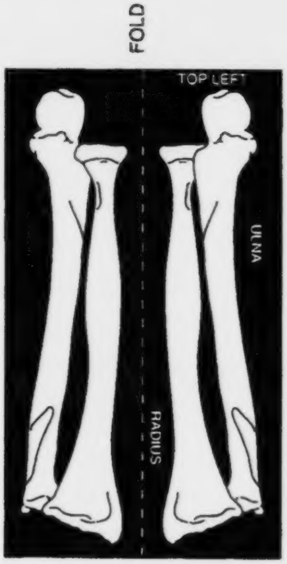
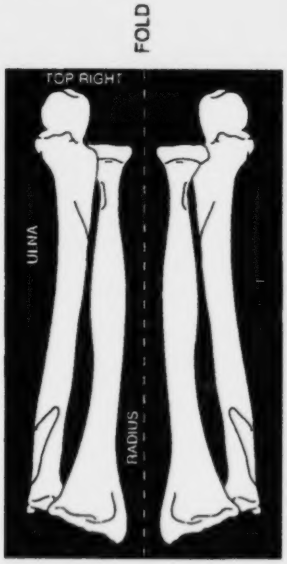
HUMERUS

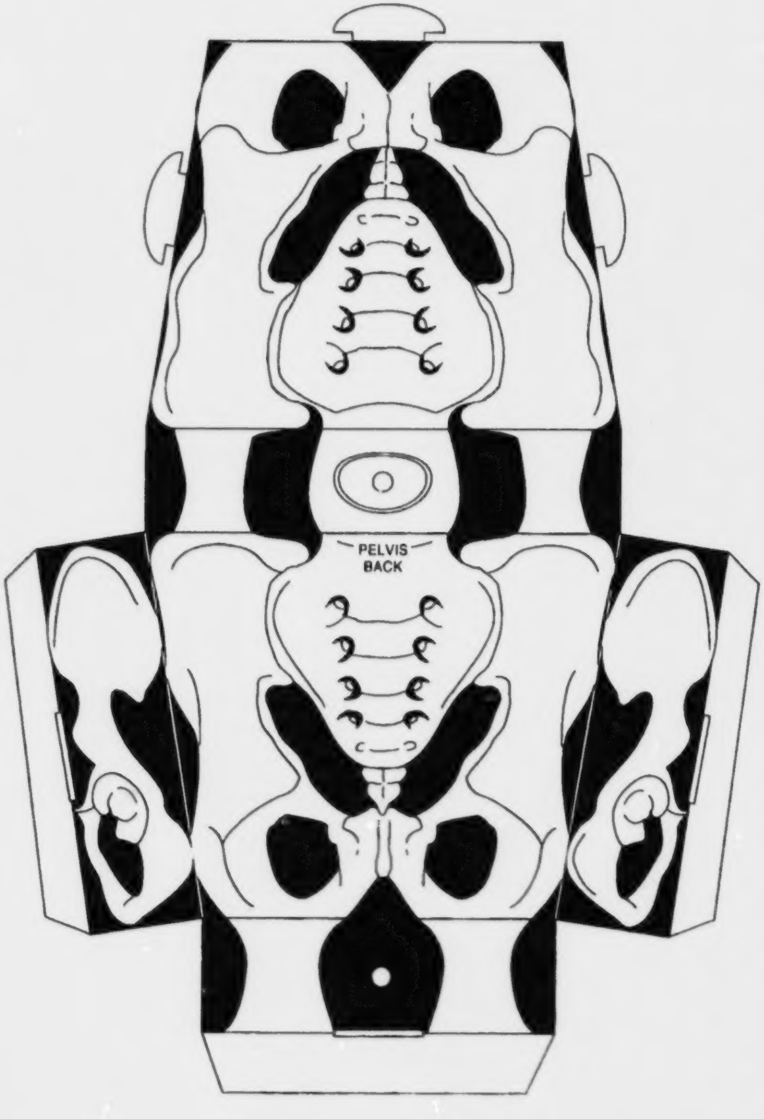

FOLD
TOP RIGHT
HUMERUS

RADIUS AND ULNA

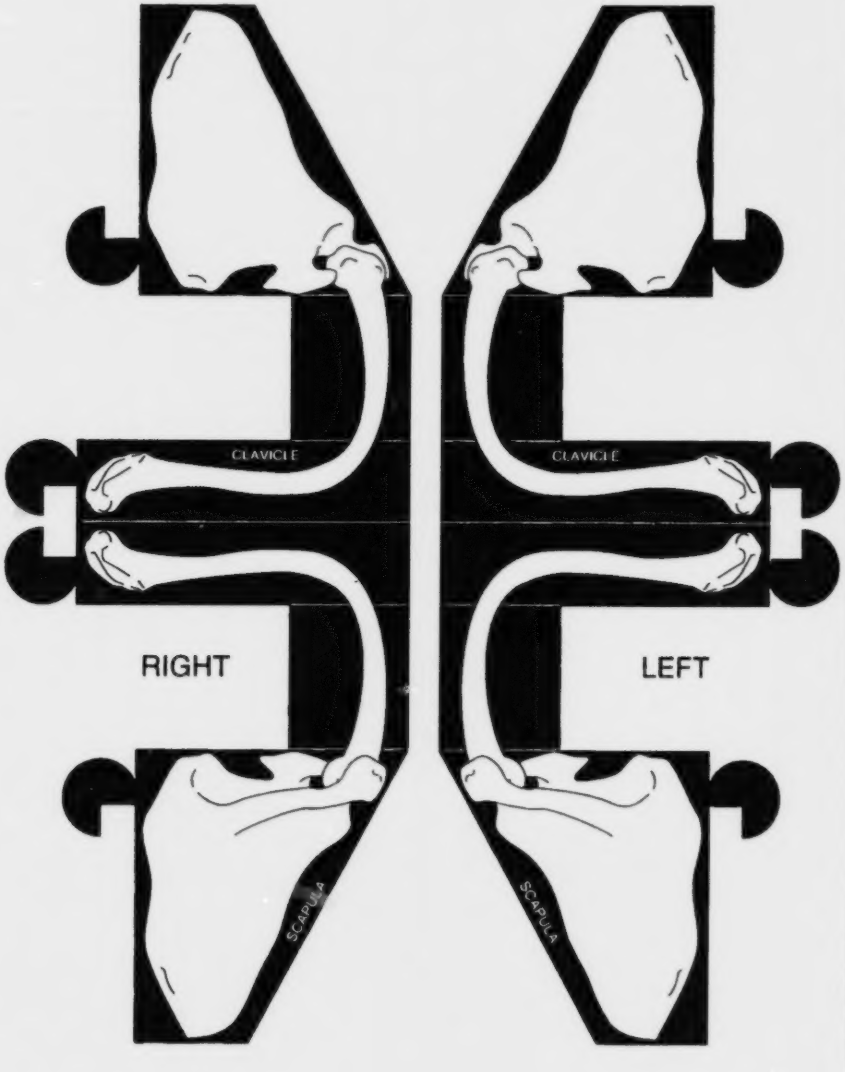

FOLD
TOP LEFT
ULNA
RADIUS


FOLD
TOP RIGHT
ULNA
RADIUS

PELVIS

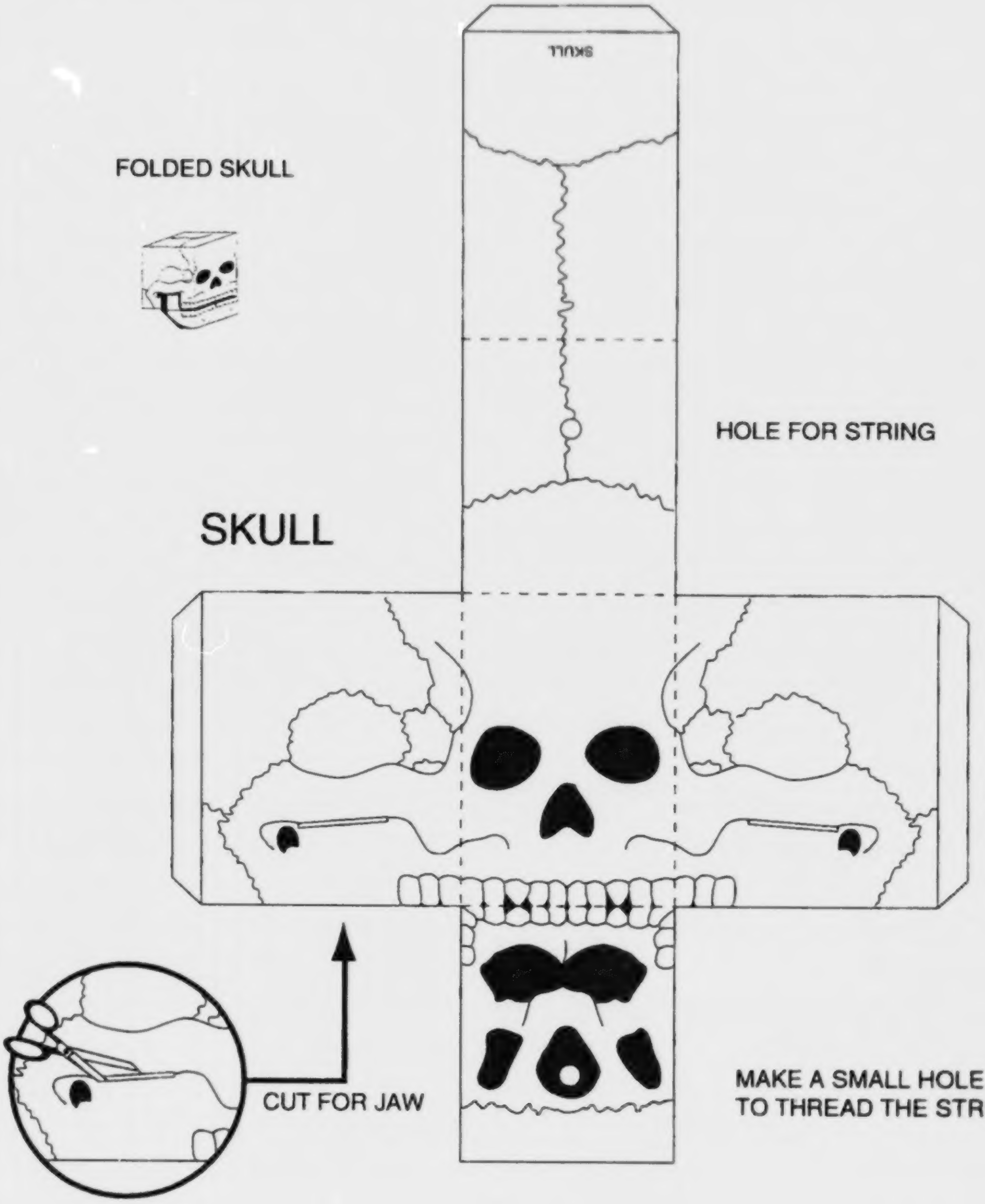

PELVIS
BACK

CLAVICLES AND SCAPULAE


CLAVICLE
CLAVICLE
RIGHT
LEFT
SCAPULA
SCAPULA

FOLDED SKULL

SKULL



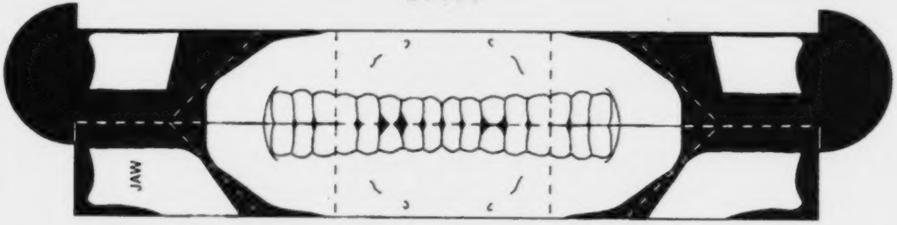
HOLE FOR STRING

CUT FOR JAW

CUT FOR JAW

MAKE A SMALL HOLE
TO THREAD THE STRING

JAW



DASH

Name________________________

Date________________________

STUDENT PAGE 5.3.14 MUSCLES

1. **Make a diagram of the humerus, radius, ulna, and the muscle that flexes the forearm. Show the insertion and the general area of the origin of the muscle. Label the bones, the muscle, and the muscle's insertion and origin.**

2. **Refer to the mnemonic below as you carry out the activities.**

MOBILE MNEMONIC

Muscles move our body's bones. A muscle is secured or held fast at its
Origin to move a
Bone connected at the other end at a spot called the
Insertion. When the muscle shortens or contracts by bulging, it can
Lift the bone. When the muscle
Elongates or relaxes, the bone returns to its starting position.

Make a diagram of the humerus, radius, ulna, and the muscle that extends or straightens the forearm. Show the insertion and the general area of the origin of the muscle.

Name______________________________

insertion and the general area of the origin of the muscle. Label the bones, the muscle, and the muscle's insertion and origin.

3. Make stick diagrams showing the pelvis, upper and lower leg, and foot in the movements listed. Show the muscle or muscles producing each movement. Label the origin and insertion. Include the following movements and any others you may have explored.

- Lifting the upper leg up.

- Pulling the upper leg down.

Name________________________________

- **Pulling the front of the foot down to walk on the toes.**

- **Raising the front of the foot up to walk on the heel.**

DASH

Name ______________________________

Date ______________________________

STUDENT PAGE 5.3.15 MUSCLE NAMES

1. Write the common names for the muscles identified in the Figures SP 5.3.15(1–2).

2. Name the muscles that could

   - Pull the upper arm (the humerus) up.

     ____

   - Pull the upper arm (the humerus) down.

     ____

   - Pull the upper leg (femur) up.

     ____

   - Pull the upper leg (femur) down.

     ____

   - Pull the front of the foot down to walk on the toes.

     ____

   - Pull the front of the foot up to walk on the heel.

     ____

ILLUSTRATIONS

Name ______________________________

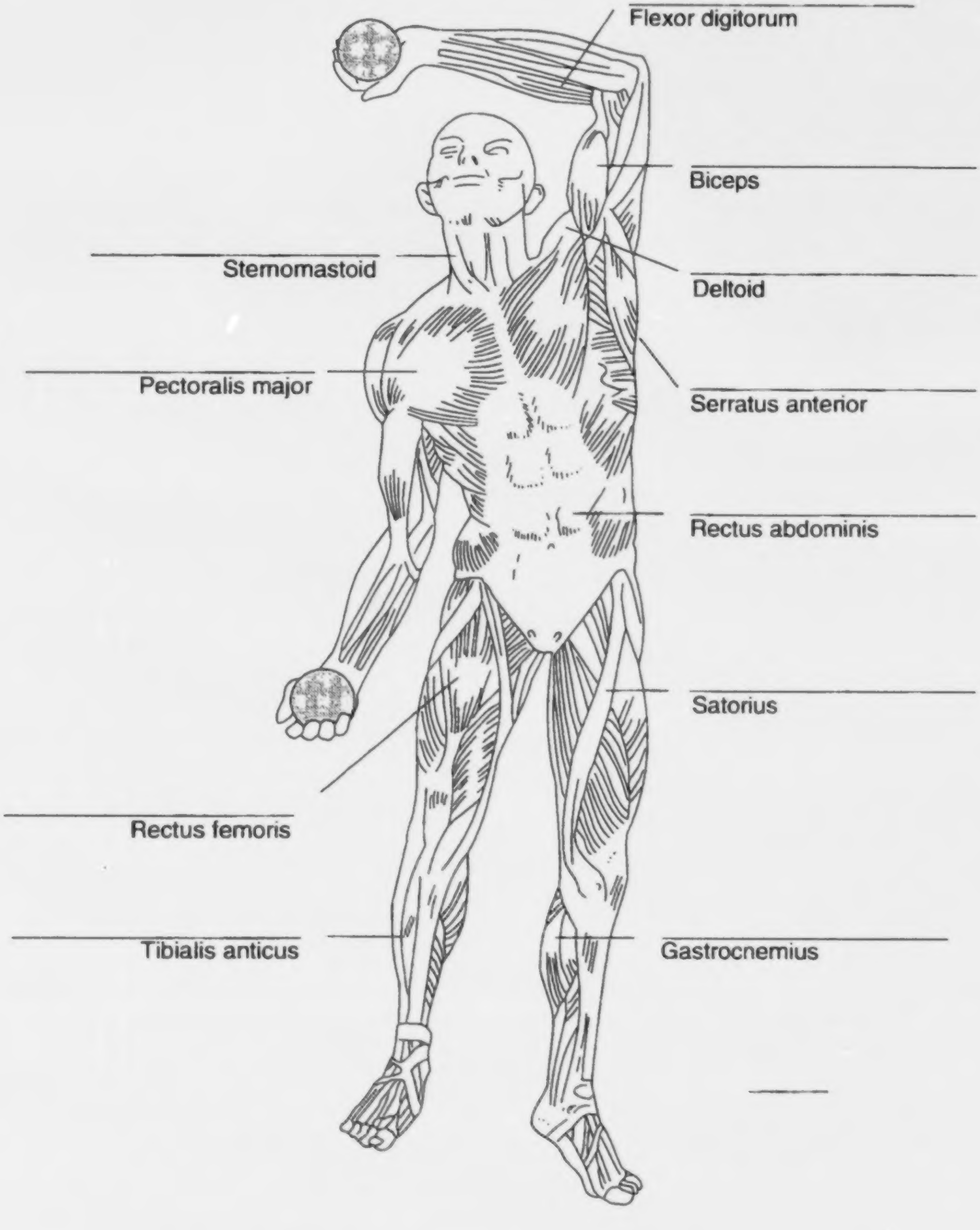

Flexor digitorum
Biceps
Sternomastoid
Deltoid
Pectoralis major
Serratus anterior
Rectus abdominis
Satorius
Rectus femoris
Tibialis anticus
Gastrocnemius

Figure SP 5.3.15(1) Common and scientific names of muscles of the body (front view)

Name __________________________

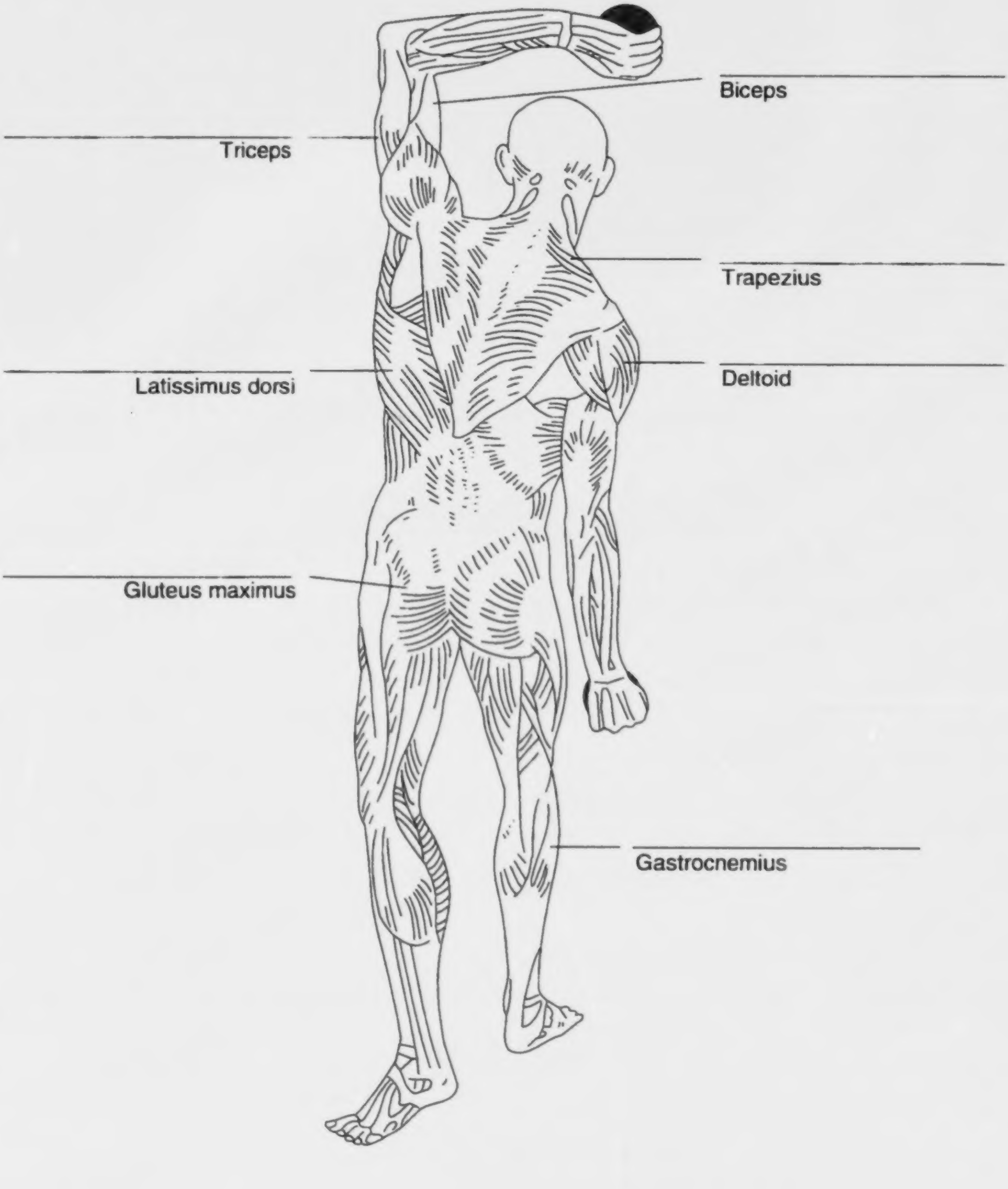

Biceps
Triceps
Trapezius
Latissimus dorsi
Deltoid
Gluteus maximus
Gastrocnemius

Figure SP 5.3.15(2) Common and scientific names of muscles of the body (back view)

DASH

Name____________________________________

Date____________________________________

STUDENT PAGE 5.3.16 CHEMISTRY AND BONES

1. List bone-like materials that animals produce in their bodies.

2. Explain what we mean by digestion.

3. Describe the materials to be tested in chemical digestion.

Name ______________________________

4. Make a separate data table and daily record for each material tested.

   Include
   - observations
   - the ph of the solution
   - the mass of the material

5. Describe how you evaporated away the liquid that remained after the reaction was complete. Explain why you selected the means you chose to speed up the evaporation.

6. Describe what was left after you completed your evaporation.

Name____________________

Date____________________

STUDENT PAGE 5.3.17 SENSES

1. List the senses of the body.
   - Indicate where you think each of the senses is located in your body.
   - Indicate any special organ used in the sensing process.

SENSES	BODY LOCATION	SPECIAL ORGAN

2. Describe how you explored the sense of taste and what you found.

Name____________________________

3. Describe your investigation of sensory receptors in the skin.

DASH

Name____________________________

Date____________________________

STUDENT PAGE 5.3.18A THE EYE

1. **Draw your partner's eye and other body parts that help in sight and protection. Label these parts.**

2. **Describe what the colored ring (the iris) does in response to intense light.**

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Name________________________

3. Label the diagram of a dissected eye.

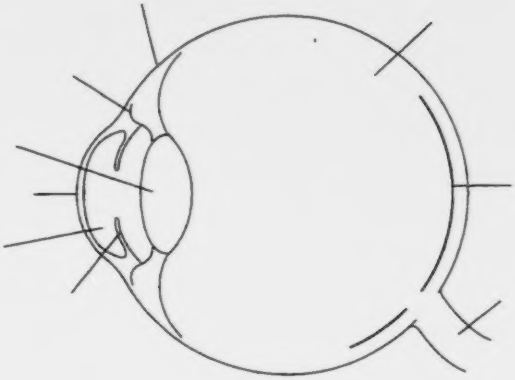

Figure SP 5.3.18A The dissected eye

4. Draw your box model of the eye, label the parts, and explain how it works compared to a real human eye.

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Name________________________

5. Describe how thick and thin lenses of the same diameter differ in their focal lengths.

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6. Explain how the eye adjusts to keep both things at a distance and things that are close at hand in focus.

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DASH

Name__________________________

Date__________________________

STUDENT PAGE 5.3.18B EYE PARTS

PARTS OF THE EYE

- **The cornea** is the clear protective window through which light enters the eye. It forms a slight bulge at the front of the eyeball.
- **The iris** is a colored muscular ring around the pupil of the eye. It controls the amount of light that can enter the eye. It is the iris that gives our eyes their color.
- **The pupil** is the opening in the center of the iris through which light passes to the lens. We see it as a dark circle in the center of the eye.
- **The lens**, called the crystalline lens because it is as clear as crystal, is directly behind the iris and acts to focus light on the retina, the light-sensitive part of the eye.
- **The lens muscles** adjust the thickness of the lens and allow it to change its focus.
- **The sclera** is the tough outer protective covering of the eyeball. We see it as the "white of the eye."
- **The retina** is at the back of the eye opposite the pupil. It is the "screen" on which light is focused by the lens. The retina is a vast bed of nerve endings that pick up the image focused on it. These nerve endings are able to distinguish between different colors of light.
- **The optic nerve** is the carrier of visual information from the retina to the visual centers of the brain.
- **The fluid in *front* of the lens** is a clear, watery liquid that helps hold the shape of the cornea and protect the lens and inner parts of the eye from sudden blows. It is called the ***aqueous humor***.

Name______________________________

- **The fluid *behind* the lens** is a thick, transparent jelly that holds the shape of the body of the eyeball and takes up the impact of sudden blows. It is called the ***vitreous humor***.
- **Tear glands** are located above the eyeball on the ear side of the eyelid. These glands produce the liquid that washes foreign matter from the eye.
- **Tear canals** have openings on the inner or nose side of the eyelids—one on the upper and one on the lower lid. We can see two openings—one above and one below on the eyelid. These openings drain tear fluids into our nose. This is why that we must blow our nose when we cry.
- **Eyelids** are muscle-operated flaps of skin that can be brought over the eye to close it.
- **Eyelashes** are hairs growing on the rim of the eyelid. These hairs help protect the eye against the entry of foreign bodies.

Name________________________

Date________________________

STUDENT PAGE 5.3.19 SOUND

1. Draw your device that produces a loud sound and explain how it works.

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2. Draw your device that produces long-lasting sound and explain how it works.

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Name______________________________

3. Describe how you deadened the sound made by your device.

4. Record your hypothesis about how sound is made.

5. Describe how you tested your hypothesis about how sound is made.

6. Explain what you finally concluded about how sound is made.

DASH

Name__________________________

Date___________________________

STUDENT PAGE 5.3.20A FACTS ABOUT THE EAR

SOME FACTS ABOUT THE EAR

1. We humans can hear sound made by an object vibrating as few as 16 vibrations per second.
2. Some very young children can hear sound made by as many as 40,000 vibrations per second.
3. As we grow older, we lose our ability to hear these high-pitched sounds, and our upper range drops to about 20,000 vibrations per second.
4. Dogs hear sound made by 30,000 vibrations per second. High-pitched whistles that most of us cannot hear can be used to call them.
5. Our **outer ear** or **pinna** is a sound collector. It sends sound down the **auditory canal** to the **eardrum**.
6. Our **eardrum** is a thin covering at the far end of the auditory canal that vibrates back and forth when sound waves hit it.
7. The eardrum separates the outer ear from the **middle ear**.
8. Our **middle ear** is a small chamber in the bone of the skull between the outer ear and the **inner ear**.
9. The **inner ear** is in another set of chambers even deeper in the skull.
10. Separating the middle ear from the inner ear is a membrane surrounding the structures of the inner ear.
11. Three bones in the middle ear connect the eardrum with the membrane of the inner ear.
12. Attached to the center of the eardrum is a tiny bone called the **hammer**.
13. The hammer in turn is connected to a bone called the **anvil**, which is connected to a bone called the **stirrup**.
14. The inner ear has two purposes, sensing sound information for our brain to interpret and sensing our body's balance.
15. The sensing of sound occurs in the **cochlea**, a snail-shaped tube filled with liquid. *Cochlea* means *snail* in Latin.

Name __________________________

16. The stirrup is attached to the inner ear membrane at a spot called the **oval window,** which is located on the surface of the cochlea. The stirrup carries the vibrations from the eardrum to the fluid in the cochlea.
17. When the eardrum vibrates, the fluid vibrates.
18. Movement in the fluid is detected by tiny hairs in the wall of the cochlea.
19. Additional structures called the **semicircular canals** and the **utricle** are involved in sensing balance.
20. There is a tube running from the back of our mouth to the middle ear. It is called the **eustachian tube**. This tube helps keep the pressure of air on the inside of the eardrum the same as the pressure on the outside of it.
21. Information about sound is transmitted to the brain through the **auditory nerve**.

DASH

Name__________________________

Date___________________________

STUDENT PAGE 5.3.20B THE EAR

1. Draw the external ear of your partner. Label the parts. Estimate the depth of the canal.

2. Describe how you made your conical ear trumpet out of paper and the effect it had when you listened to someone talking softly.

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Name_______________________________

3. Label the parts of the ear using the names found in Student Page 5.3.20A FACTS ABOUT THE EAR.

4. Use the diagram in Figure SP 5.3.20B to construct a model of the ear by cutting out the parts.

    - Cut out the parts of the ear and mount them on corrugated cardboard.
    - Fold the eardrum and the oval window up so they form a 90° angle with the ear-bone system (hammer, anvil, and stirrup).
    - Attach the ear-bone system in the middle-ear chamber of the model. Use a pin or tack as the fulcrum.

5. Describe how the inner ear operates.

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ILLUSTRATION

Name ______________________________

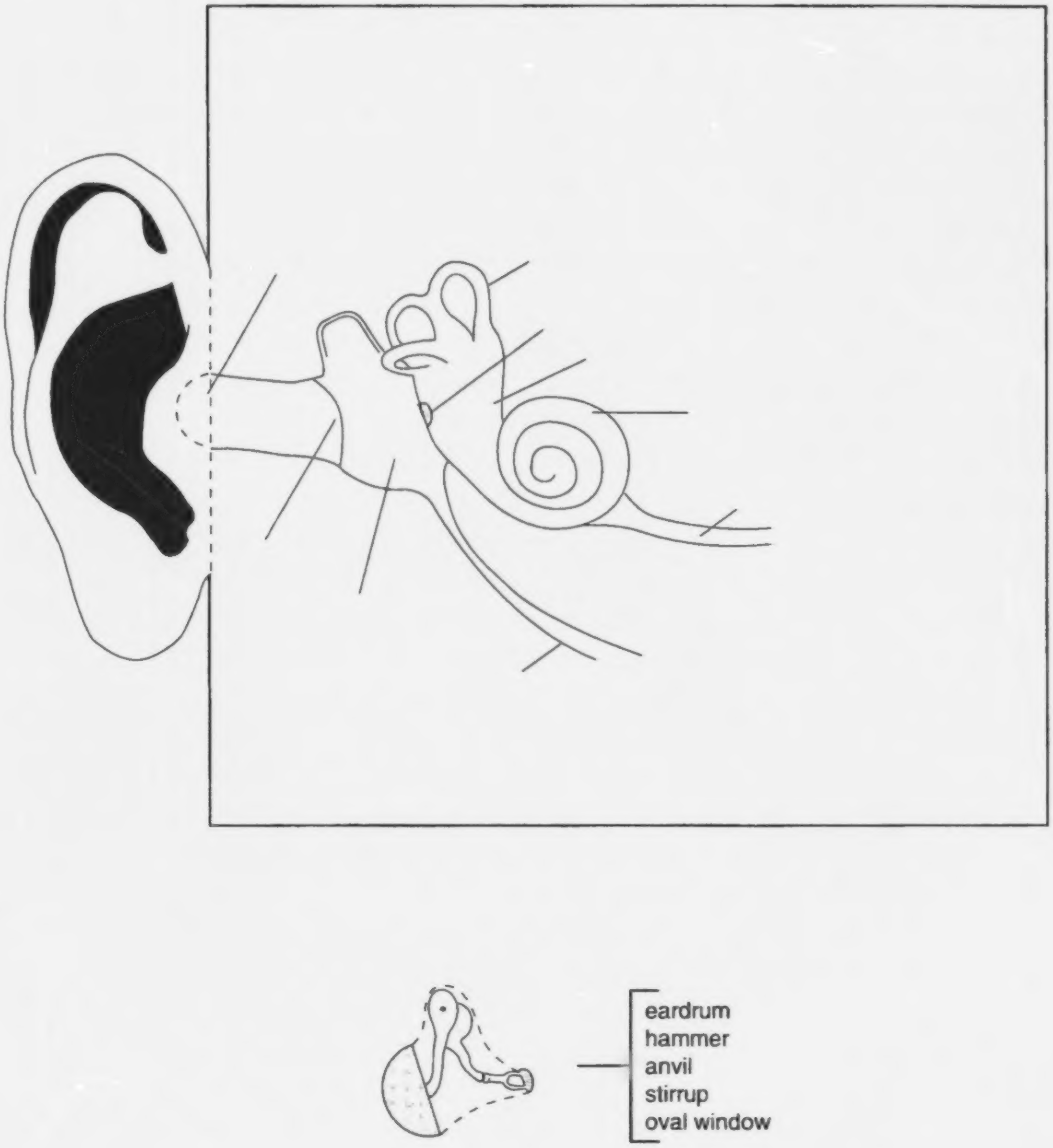
eardrum
hammer
anvil
stirrup
oval window

Figure SP 5.3.20B Working model of the ear

DASH

GRADE FIVE
CLUSTER 4

Plants

5.4.1 Annual, Biennial, and Perennial Plant Project

5.4.2 Tree Harvesting

5.4.3 Tree Planting

5.4.4 Tree Observation

5.4.5 Measuring Trees

5.4.6 Age of Trees

5.4.7 Trees, Shrubs, and Grasses

5.4.8 Grasses: Why Do They Grow There?

5.4.9 Roots

5.4.10 Soil Conservation

ACTIVITY 5.4.1 ANNUAL, BIENNIAL, AND PERENNIAL PLANT PROJECT

OBJECTIVES

The students
- Continue their research on an annual, biennial, and perennial plant project.
- Report on their project.

BACKGROUND

This activity is a follow-up to Activity 4.4.1 ANNUAL, BIENNIAL, AND PERENNIAL PLANTS. It is designed to give the students an opportunity to do self-directed research. Ideally, the activity will have been started in the fourth grade.

The Research

The research question asked in this activity is What happens to vegetable plants that are not harvested or to garden plants that don't flower in their first year of growth? The intent of the research is to characterize *annuals,* plants that live through only one season; biennials, plants that live for two seasons; and *perennials,* plants that live for more than two seasons. Some examples of annuals are beans, peas, tomatoes, squash, and pumpkins. Biennials include beets, carrots, and some bulb plants. Perennials include bamboo, asparagus, berries, shrubs, and trees.

Time Required

The problems the students are researching will require at least two growing seasons. A plant grown in a container in a sunlit window at home can be forced to grow through two growing seasons between fall and spring. Use plastic containers or cans with holes in their bottoms and pie pans to hold the water. Loose garden soil is a good growing medium.

Growing periods can sometimes be artificially activated using grow lights indoors. The length of the day influence growing patterns of some plants. Seed packages usually report optimum growing periods.

STUDENT ROLES

Botanist
Gardener

MATERIALS

seeds
cans
pie pans
sunlit window
Student Page 5.4.1 ANNUAL, BIENNIAL, AND PERENNIAL PLANT PROJECT

PRODUCTS

Container gardens
Completed Student Pages

PROCEDURES

1. **In the beginning of the year get a progress report on the students' Annual, Biennial, and Perennial Plant Project from DASH 4.**

   Have the students
   - State the questions they are trying to answer.
   - Tell how they are progressing.
   - Share any problems they are having.
   - Estimate when they will be finished with their project.

2. **Have the students who have not already started a project select a question for their research. Keep a class record so that the continued growth of perennials, biennials, and annuals is studied.**

   The following questions can be considered for research:
   - What happens to a root vegetable plant grown in the fall and continuously maintained without harvesting through the school year? Will it ever flower? (Have the students use such plants as radishes, turnips, or carrots that can be grown in cans.)
   - What happens to pod-producing vegetable plants such as peas? Will they grow again from their roots and will they flower a

second year? (Have the students use such plants as peas and bush beans that will grow in cans.)
- What happens to leaf vegetables such as lettuce or chard? Will they flower if not harvested? When? Will they continue to grow if not harvested?
- What happens to bulb plants such as irises? Will they grow again from their bulb and flower?
- Any additional questions that deal with the continued growth patterns of plants after the time of normal harvest.

3. **Have the students starting a project go through the steps of the original fourth grade assignment.**

Have them
- State a question they want to answer.
- Select a garden plant.
- Design an experiment to answer the question.
- Calculate the time needed to run the experiment.
- Plan for the maintenance of the experiment.
- Where possible use three or more plants.

4. **In the spring have the students report on their plant project.**

Have them
- Tell what question they are trying to answer.
- Tell which garden plant they selected and why.
- Describe their experimental design.
- Describe how they carried out their experiment.
- Discuss their findings.
- Discuss further questions that their work might lead to.

5. **Summarize the activity by having the students develop working definitions of perennial, biennial, and annual plants.**

Ask such questions as these:
- What might be meant by an *annual plant?* (Work to the idea of one that lives for a year.)
- What is meant by the term *biennial plant.* (Work to the idea of one that lives for two years.)
- What is meant by the term *perennial plant.* (Work to the idea of one that lives for more than two years.)

- Which of the plants you have grown fit into the category of annuals, which in biennials, and which in perennials?
- What is a characteristic growth pattern of an annual?
- What is a characteristic growth pattern of a biennial?
- What is a characteristic growth pattern of a perennial?

EXTENSION

- Have the students do further research on one of the questions suggested by this work.

DASH

Name

Date

STUDENT PAGE 5.4.1
ANNUAL, BIENNIAL, AND PERENNIAL PLANT PROJECT

1. Record the question you have decided to research.

2. Name the garden plant you selected and tell why you selected it.

3. Describe your experimental design.

Name________________________________

4. Describe how you carried out your experiment.

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5. Discuss your findings.

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6. Record your working definition for the term *annual.*

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7. Record your working definition for the term *biennial.*

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8. Record your working definition for the term *perennial.*

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ACTIVITY 5.4.2 TREE HARVESTING

OBJECTIVES

The students
- Hold a tree-cutting and decorating celebration.
- Harvest a tree they have watched mature.
- Summarize the growth information collected on the tree.
- Emphasize the idea that tree planting and harvesting require long-term planning.
- Look at the life history of the tree and compare the tree's growth characteristics with those of trees cut in previous years.

BACKGROUND

This activity should be followed by Activity 5.4.3 TREE PLANTING in the spring of the year. Ideally each year right before the winter holidays DASH fifth graders harvest a tree that was planted three years earlier when they were second graders. The cutting of the tree has the symbolism of receiving a tree from another generation as part of a heritage. They also go on an archeological hunt to find the time capsule in which former fifth-graders buried records of the planting of the tree. The map for locating the site where the capsule was buried should be found in the library.

Cutting the Tree

The cutting of the tree can be done as either a private or a public ceremony by the fifth graders. After the students measure the tree and record the history of its growth, they may want to decorate it.

Reflections

The students should reflect on the life of the tree, comparing its growth characteristics with those of trees planted and harvested in previous years. This is a time for remembering how when they were younger a fifth-grade class planted the tree they will harvest. It is a time for reflecting on why each generation plants trees for the next generation.

Measurements

Shadow diagrams can be made by securing paper on a flat surface such as a piece of plywood 4 ft x 8 ft. The paper should be placed vertically behind the tree so that the early morning shadow can be traced on it. Ideally, shadow diagrams should be made right before the winter holidays and as close to sunrise as possible. Light coming in nearly parallel with the ground will provide a shadow that is not distorted. The shadow should be drawn quickly since it will move. The area of the shadow can be estimated by seeing how many squares 10 cm x 10 cm can be laid on the surface. If a shadow drawing is not possible, have the students invent a way to trace the outline on the paper suspended behind the tree while it is still standing or when it is lying down.

Tree Rings

Rings will be probably visible when the trunk is cut. In all but tropical regions, usually one ring will have been laid down for each growing season. The students will discover this when they correlate the number of rings with the age of the tree. The count of the years and the count of the rings will be the same. In the tropics where there is no winter interruption in growth, the rings will usually correspond to the number of wet periods.

STUDENT ROLE

Tree grower

MATERIALS

records of the tree from the library
a saw
a holder for the tree
butcher paper to make a shadow drawing.
paper to make 10 x 10-cm squares
meter-string can
decorating materials as needed.
Student Page 5.4.2 TREE HARVESTING

PRODUCTS

A harvested tree
The library record
Completed Student Pages

PROCEDURES

1. **Explain that it is just about the time of the winter solstice and time to harvest our holiday tree. Have the students plan a celebration to cut their tree and decorate it.**

Help the students decide
- Who will attend the tree-cutting celebration.
- Who will speak about passing on the heritage of the tree.
- What decorations they are going to make for the tree. (This could involve an interclass contribution of ornaments, garlands, and so forth.)
- How they are going to keep the tree erect. (Have them invent a base.)
- How they are going to keep the trunk in water. (This is a time to review the importance of keeping the tree moist so that it does not dry out and become a potential fire hazard.)

2. **Have the students prepare a growth analysis of their tree for display at the celebration. Use Student Page 5.4.2 TREE HARVESTING.**

Have the students
- Retrieve the growth record of their tree from the library.
- Retrieve any previous growth records of other trees for comparison with their tree's records.
- Make their annual height, shadow, and circumference measurements of their tree. (Any shadow measurements should be made early in the morning or in the late afternoon when the sun is near the horizon.)
- Make a large display graph of changes of height and circumference over time.
- Make a display of shadow diagrams

3. **Analyze the growth information.**

Ask such questions as these:
- Which of the measurements has changed the most, the shadow area, the height, or the circumference?
- How much change in circumference was there for each increase of a meter in height?
- How can you find such a relationship? (Work for agreement that they could graph the data or divide the circumference by the number of meters that the tree has grown in height. For example, if the tree has grown 1.6 m and increased 8 cm in circumference, the ratio would be 5 centimeters per meter.)
- How can we show changes in shadow area over the three years? (Get at making a graph. Have the students do this.)

- How can you estimate the area of the shadow diagram? (Help the students invent a method to estimate the area such as laying 10 x10-cm squares over the surface of the shadow diagram.)
- How high would you project the tree to be next year? In five years? What would be the size of its shadow area in a year? (Have the students extrapolate from their graphs.)

4. **Have the students retrieve the map showing the location of the time capsule with the record of the planting of the tree.**

Have the students
- Find the capsule. (This can be part of the celebration.)
- Inspect the capsule for decomposition and other damage.
- Record recommendations for building a capsule.
- Keep the capsule to show the second graders.
- Display the contents of the capsule. (If a videotape was buried in the capsule, play it.)

5. **Hold the cutting and decoration celebration.**

Have the students
- Carry out any formal part of the celebration.
- Cut the tree.
- Observe and count the rings.
- Observe any flowing sap.
- Immediately put the base of the tree in water to keep the tree from drying.
- Decorate the tree.

6. **Analyze the rings with the students.**

Ask such questions as these:
- How old was our tree when it was planted?
- How many rings are there?
- How old is our tree now?
- How does the number of growth rings compare with the number of years the tree has lived? (In temperate zones they will probably be the same; in the tropics the number of rings will probably reflect the number of wet seasons.)

- What might the growth rings represent?
  (Get at the idea of a growing season. Trees in temperate zones grow most in the spring, summer, and fall. They usually stop or greatly slow down their growing during the winter. When this happens, the outer edge of new wood changes color, producing a ring. Usually there will be as many rings as there have been winters.)
- Compare the growth characteristics of their tree with those of trees harvested in previous years.
- Are some rings wider than others?
- What was our weather like in the years when the rings are wide?
  (Years of wide growth rings are usually years when there was mild weather and a great deal of rain.)

7. **When the tree is taken down, have the students decide how they wish to recycle it.**

   Help them consider such things as these:
   - Shredding it for the third grade compost.
   - Making the tree into a bird feeder.
   - Using the cut-up trunk and branches as building materials.

EXTENSIONS

Have the students research
- The history of tree decoration.
- The history of seasonal celebrations at the winter solstice.
- Tree farming.

Name____________________________

Date_____________________________

STUDENT PAGE 5.4.2 TREE HARVESTING

1. Graph the tree's change in height since it was planted.

Name_______________________________

2. Graph the tree's change in circumference since it was planted.

3. Explain how you measured the area of the shadow pictures of the tree.

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Name________________________________

4. Show your calculations of the amount of increase in circumference that took place for each meter increase in height.

5. Show your calculations of the amount of increase in height that took place compared to increase in the shadow area. Measure the shadow in squares 10 cm on a side.

6. Draw the rings of the tree the same size as they appear in the cutting.

Name________________________________

7. **How does the age of the tree seem to relate to the number of rings?**

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8. **How does the weather seem to have affected the growth of the tree's annual rings?**

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ACTIVITY 5.4.3 TREE PLANTING

OBJECTIVES

The students
- Plant a tree to be the inheritance of another group of students.
- Observe that tree planting, maintenance, and harvesting require long-term planning.
- Observe that replanting replenishes the stocks of trees that have been harvested.
- Observe that trees are a renewable resource.
- Create a record of the tree planting, including the tree's height, circumference, and shadow profiles.
- Hold an Arbor or Earth Day replanting ceremony.
- Make and bury a time capsule to keep a record of the event.

BACKGROUND

In this activity the students plant an evergreen tree. The activity should be done in conjunction with Activity 5.9.3 DECOMPOSITION AND ARCHEOLOGY. The tree will be harvested near the winter holidays three years in the future when today's second graders are fifth graders. A heritage will be passed on. A tree-planting ceremony is suggested and a time capsule carrying the record can be buried to be retrieved when the tree is harvested.

Measurements

The students record the height of the tree and make a shadow profile of it on butcher paper. The shadow profile can be drawn in the classroom before the tree is taken outside for planting.

Keeping Records

If possible, records of the tree's height and circumference should be kept in the library along with its shadow profiles. A map of the site where the time capsule was buried should also be kept. All these records can be withdrawn when the second graders cut the tree three years in the future. Second graders who will take over responsibilities for the tree should be present at the planting. A logical time for the planting of the tree is Arbor Day or Earth Day.

STUDENT ROLES

Forester
Tree farmer

MATERIALS

butcher paper
shovels
picks
small evergreen tree
hose
fertilizer as required.
Student Page 5.4.3 TREE PLANTING

PRODUCTS

Planted tree
Records of tree growth
Completed Student Pages

PROCEDURES

1. **Have the students research Arbor Day or Earth Day if this is when the tree will be planted.**

   Ask such questions as these:
   - What is being commemorated on this day?
   - When was this day first commemorated?
   - Why was this day established?
   - Why should we plant trees for someone else's use?
   - Why do we replant after we harvest?
   - How long must one wait after planting to harvest fruit trees? (This will usually be four to ten years, depending on the kind of tree.)
   - How long must one wait to harvest timber trees? (Timber trees take 20 to hundreds of years to mature. Some other trees take three to five years.)
   - Why is there such a difference in time? (Most fruit trees become producers early in their development. When the body of the tree is harvested for wood, however, it should have as much bulk as possible, and wood grows slowly.)

- What has to be done to a tree while we are waiting to harvest it? (Get at the idea that if the tree stands in the forest, probably nothing. However, if it is farmed, it may need to be fertilized, pruned, protected from insects, and perhaps irrigated.)
- What do we mean when we say that trees are a "renewable" resource? (Work to the idea that we can grow trees, harvest them, and plant and grow others in an endless cycle. Nonrenewable resources such as copper and silver cannot be grown or made by our technology. Once the supply is exhausted, there will be no more on our planet. Oil and coal are other examples of nonrenewable resources. It takes millions of years for the processes of nature to produce coal and oil.)
- How can we replace the tree we have harvested to give it to another generation of fifth graders to use? (Work to agreement that they can plant another tree.)

2. **Have the students plan a tree-planting ceremony. Have them work with the second graders for whom they will plant the tree.**

   Ask such questions as these:
   - How are the second graders to be invited?
   - Who else is to be invited? (Principal, other classes, parents, and others.)
   - What speeches, presentations, and so forth are to be made? (This is an ideal time to have the students write essays and make posters on trees and conservation. See Extension.)
   - Where are we going to get the tree?
   - How is the soil prepared for planting a tree?
   - How are we going to record the dimensions of the tree? (Work to the idea of making a shadow profile of the tree from the side and recording the height and circumference of the tree right above the soil line.)
   - How are we going to record the event for the time capsule? (Photos, drawings, videotapes, and so forth.)
   - How are we going to preserve our records? (Work to the idea of using the library and the time capsule from Activity 5.9.3 DECOMPOSITION AND ARCHEOLOGY as repositories.)

3. **Have the students carry out their plan for a tree-planting ceremony.**

4. **Have the students use Student Page 5.4.3 TREE PLANTING to help summarize what they have learned.**

EXTENSION

Have the students write an essay on one of the following topics:

- Tree planting to renew resources.
- The extent of America's timber forests.
- Uses of wood in America.
- Uses of wood worldwide.
- Past, present, and future needs for wood.
- The Christmas tree industry.

Name________________________

Date________________________

DASH

STUDENT PAGE 5.4.3 TREE PLANTING

1. **Explain why we replant after trees after we harvest them.**

2. **Explain why each generation must consider the needs of generations to come as we deal with our environment.**

ACTIVITY 5.4.4 TREE OBSERVATION

OBJECTIVES

The students
- Observe and compare conifer and broad-leafed trees for a year.
- Make tree-history boards.
- Report on the economical value of the species of conifer and broad-leafed trees they have studied.

BACKGROUND

Plant study is a major topic in DASH that begins in kindergarten. In DASH 5 the students observe a pair of trees for the full school year. Ideally, the students will have different pairs of trees to get as much variety as possible. One tree should be a conifer. *Conifers* are members of the pine family and have scaly or needle-like leaves. The other trees should be broad-leafed. If palms are common to your region, add them to the observation set. This activity will normally need to be done off the school grounds as an independent study with direction.

Collections

The students should start their observation and recording early in the school year. Their year-long investigation should include making collections of the following:
- *late-summer* leaves, twigs, fruits, and seeds
- *fall* leaves, twigs, fruits, and seeds
- *winter* leaves and twigs
- *spring* leaves, twigs, buds, and flowers
- *early-summer* leaves, twigs, buds, and flowers

Leaves and Flowers

A herbarium press can be used to preserve their leaves and flowers. To preserve specimens place them on white paper. Cover them with plastic wrap and put several sheets of newspaper above and below them to absorb moisture. Make a stack of materials to be pressed then put a board on the top of the newspaper and a heavy weight on top of the board. The specimens should be pressed until they are dry. One or two presses will normally handle all the pressing needs of the class at one time.

Fruit and Seed

Have the students keep any seed pods they find and dry them. If the fruit is pulpy, have them cut it open and draw it in cross section, showing the location of the seed. Also have them draw the uncut fruit. Photos will give added precision to any display.

Fruits can also be dried in the sun. Cover the bottom of a box with plastic wrap. Open the fruits to expose the pulp and lay them on the plastic wrap. Cover the box with cheesecloth to keep out flies. Turn the fruits every few hours. Bring the fruits inside in the afternoon and do not let them get wet. An apricot will dry in several days.

Twigs and Buds

Have the students cut short pieces of twigs with a knife or scissors to show the wood grain. They should make a final smooth cut with a knife or razor blade. In the spring have them select twigs that show the first leaf and flower buds.

Display

The pressed leaves, flowers, twigs, and seeds can be glued to a single large sheet of cardboard to tell the story of a year in the life of a tree. If paper is used, it will probably have to be attached to corrugated cardboard to give it stability.

Location of Trees

Trees may be found in urban, farm, and forest environments. The students should note the kind of environment when they describe the location of their trees.

Identification of Trees

Any available field guide to trees will help in identification. The Golden Nature Guide, Peterson Field Guide and Audubon series are very helpful.

STUDENT ROLES

Forester
Botanist

MATERIALS

cheesecloth
large sheets cardboard or white paper for mounting
newspaper
board for plant press
weight for plant press
tree field guides
scissors or knife to cut twigs
white glue
plastic wrap
Student Page 5.4.4 OBSERVING TREES

PRODUCTS

Tree-History Boards
Completed Student Pages

PROCEDURES

1. **In the late summer or early fall, explain to the students that we need to get a clear picture of what happens to trees throughout the year.**

   Have them
   - Find a conifer (some member of the pine family) that they can observe all year. Conifers have needle-like or scale-like leaves and bear cones. (Show some examples. Have the students bring in needles or scale-like leaves to verify that they have a conifer.)
   - Find a broad-leafed tree. (Show some leaves. Again have the students bring in a leaf for verification.)
   - Collect and bring to school several growing leaves, a small fresh twig, and an example of the fruit, seed, or seed pod of both kinds of trees.
   - Press the leaves, dry the seed pods, and draw pulpy fruits both cut-open and intact. Show the location of seeds. (Photos can also be taken; however, the drawing of fruit can be an exciting art task, and things will be seen while drawing that are not normally noticed in a photograph.)
   - Mount and store the first collection of leaves, twigs, and drawings to be added to each season.

2. **Have the students make field observations of their trees. Have them use Student Page 5.4.4 TREE OBSERVATIONS.**

   Have the students
   - Draw maps showing the location of their trees so that someone else can find them.
   - Find a spot where their selected trees are completely visible and sketch their shape, taking care to show approximate proportions. (This may require some practice. They can use a pencil as a sighting tool.)
   - Record what the covering of the ground is like. (Grassy, bare, vine-covered, and so forth.)
   - Identify any other trees and other plants that are near each of their trees.
   - Measure the circumference of their trees. (If students have difficulty, have them uses their meter-string cans. Refer them to Student Page 5.4.5 MEASURING TREES.)
   - Measure and calculate the height of their trees. (If students have difficulty, refer them to the Activity 5.4.5 MEASURING TREES.)
   - Estimate the age of the trees. (Refer to Activity 5.4.6 AGE OF TREES.)

3. **Have the students use a field guide to identify their trees and then make a study of the economic uses of their trees now and in times past. (First clues to economic value will be found in most field guides.)**

4. **Have the students observe any animals that use the tree and record how they use it.**

   Have them record
   - Birds that eat the fruits or seeds.
   - Birds that nest or roost in their trees.
   - Insects that feed on their trees.
   - Insects that lay their eggs in their trees.
   - Other animals that live in or under their trees. (Squirrels or other rodents, foxes, and so forth.)

5. **Have the students collect specimens and make observations at least five times during the year if possible.**

Collection and observation should be done in the

- Late summer.
- Fall.
- Winter.
- Early spring.
- Late spring or early summer.

6. **Have the students make Tree-History Boards identifying the displayed items with the seasons.**

7. **Have the students report on their findings about their trees, including differences between conifers and broad-leafed trees.**

EXTENSIONS

- Keep the best of the Tree-History Boards for display in the school or other place where student materials are honored.
- Make a collection of tree histories for reference in later years.

DASH

Name____________________________

Date_____________________________

STUDENT PAGE 5.4.4 OBSERVING TREES

1. Draw maps to show the locations of the trees you selected for observation so that someone else can find them.

2. Sketch the shape of your trees, taking care to show their approximate proportions.

Name________________________________

3. **Describe the covering on the ground beneath your trees.**

4. **Describe other trees and plants that are near your trees.**

5. **Measure and record the circumference of your trees.**

6. **Measure and record the height of your trees. Tell how you made the measurements.**

Name________________________________

7. Describe the animals that use the trees. Include
    - birds that eat the fruit or seed
    - birds that nest or roost in the trees
    - insects that use the trees for food
    - insects that lay their eggs in the trees
    - other animals living in or under the trees

8. What economic value, if any, do these trees have? Explain.

9. In what ways do broad-leafed trees differ from conifers?

ACTIVITY 5.4.5 MEASURING TREES

OBJECTIVES

The students
- Invent a way of measuring the height of trees.
- Invent a way of measuring the circumference of trees' foliage.
- Measure the circumference of tree trunks.

BACKGROUND

This activity is a companion of Activity 5.4.4 TREE OBSERVATION. For many classes the student pages can be given to students, and they will be able to work directly from them. Usually there will be enough expertise in the student group to help those having difficulty.

Where appropriate, get a forest manager or timber expert to talk to the students about the lumber value of trees. Ask them for rules of thumb in estimating the board feet in common timber trees of the region.

Height

DASH students begin using their fists to estimate angles in grade 4. One fist held at arm's length makes an angle of 10° with the eye. By piling one fist on top of another, we can measure the angle from our line of sight to the top of a tree. See Figure 5.4.5.

A 45°/45°/90° triangle has the virtue of having two sides the same length. By moving to a point where the angle made by the fist from line of sight to the tree's top is 45°, we can get a good estimate of the tree's height. Notice that it is necessary to add one's own height to the measured height.

For example, a person 1.6 m tall standing 6.4 m from a tree measures an angle of 45° from the line of sight to the tree's top. The height of the tree would be the sum of 6.4 m and 1.6 m or 8.0 m.

Another method to get a 45° angle uses a stick the same length as the arm. Hold this stick straight up at arm's length. Sighting to the top of the stick makes a 45° angle. Follow the same steps as with fists.

Trunk Circumference

The circumference of tree trunks can be measured with a meter-string can.

Circumference of Foliage

The circumference of a tree's foliage can be approximated by pacing along its noon shadow or by laying a meter-string around the shadow. An estimate of the foliage circumference can be made using the average diameter of the noon shadow. To do this measure the diameter of the shadow at several points and average the measurements. Use the formula

$$\text{Circumference} = \pi \times \text{Diameter}.$$

Because π (3.14) is very close to 3 in value, the students can think of circumference as being about 3 times the diameter.

Practice

It is a good idea to have the students practice making measurements at school. The items they measure need not be trees.

STUDENT ROLES

Forester
Forest manager

MATERIALS

meter-string can
stick 1 meter long
Student Page 5.4.5 MEASURING TREES

PRODUCTS

Completed Student Pages

PROCEDURES

1. **Have the students discuss measurements they might make of trees to follow changes over time.**

   Help them include such things as these:
   - Height of the tree.
   - Circumference of the trunk.

- Circumference of the tree's foliage. (The circumference of the outline made by the leaves if one were looking straight down on the tree.)
- Number of major branches.

2. **Have the students invent a way to estimate the height of a tree using triangles.**

3. **Discuss the task of measuring the circumference of a tree trunk. Work for agreement on where to make the measurements on the tree.**

4. **Have the students invent a way to measure the circumference of the foliage.**

   Help them include such things as these:
   - Using midday shadows.
   - Dropping string from foliage.
   - Pacing off the perimeter while holding a stick to touch the outer edge of the foliage.

EXTENSION

- Invite a forester, forest manager, or agent of the Fish and Wild Life Service to talk about measurement of trees and how it is important in forest management.

ILLUSTRATION

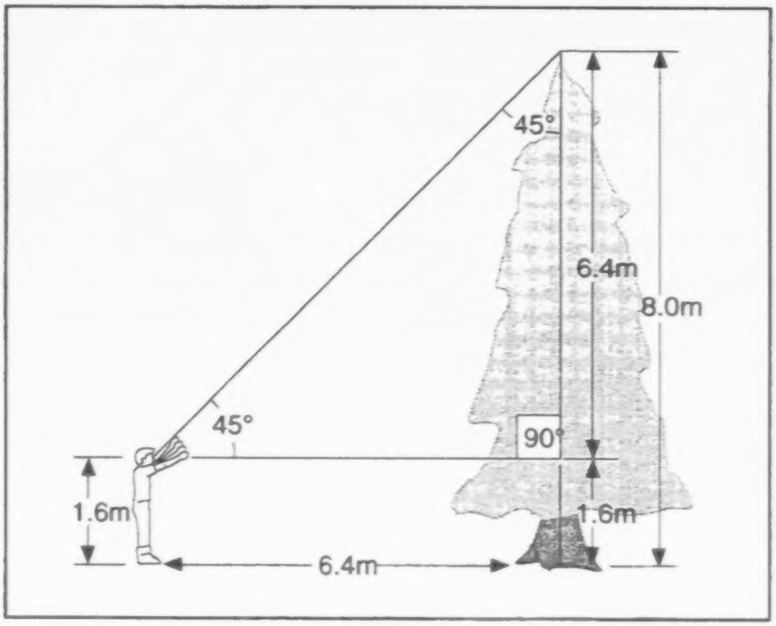
45°
45°
6.4m
8.0m
90°
1.6m
1.6m
6.4m

Figure 5.4.5 Measuring a tree

DASH

Name________________________

Date________________________

STUDENT PAGE 5.4.5 MEASURING TREES

1. Record the height of your trees and describe the method you used to arrive at the figures.

2. Record the circumferences of your trees' trunks.

3. Record the foliage circumferences of your trees and describe the method you used to arrive at the figures.

ACTIVITY 5.4.6 AGE OF TREES

OBJECTIVES

The students
- Read about methods of determining the age of trees.
- Determine the age of trees they are observing.

BACKGROUND

This activity is meant to be a companion to Activity 5.4.4 TREE OBSERVATION. It suggests methods to determine the age of the trees that the students are observing.

It is often possible to find how old a tree is by asking long-time residents, town park employees, or foresters. In some cases trees of identical species and size may have been cut to promote the growth of surrounding trees. It may be possible to find stumps with rings that can be counted. Where possible have the students carry out this activity working from the information in Student Page 5.4.6A DETERMINING THE AGE OF TREES or other references.

STUDENT ROLES

Forest manager
Botanist

MATERIALS

Student Pages 5.4.6A DETERMINING THE AGE OF TREES
5.4.6B THE AGE OF TREES

PRODUCTS

Completed Student Pages

PROCEDURES

1. **Have the students suggest things to look at in determining the age of trees.**

Help them include such things as these:
- The height of the tree.
- The circumference of the tree trunk.
- The history of surrounding trees.
- The growth rings of the tree.

2. **Have the students read the information in Student Page 5.4.6A DETERMINING THE AGE OF TREES.**

3. **Have the students estimate the age of the trees they are observing and report how they made their determination. Have them use Student Page 5.4.6B AGE OF TREES to record what they have found.**

EXTENSIONS

Have the students
- Locate some of the oldest trees in the region.
- Observe the growth rings visible in lumber.
- Invite a forester or naturalist to demonstrate and talk about methods used to find the age of trees.

DASH

Name______________________

Date______________________

STUDENT PAGE 5.4.6A DETERMINING THE AGE OF TREES

- **How might growth rings tell us the age of a tree?**

  When a tree is cut, you may be able to see a series of rings like those in a target. Each ring represents a growing season. For most trees this will also represent a year's growth. In temperate zones the number of rings usually equals the age of the tree in years.

- **When might the rule "one ring, one year" not be true?**

  In places such as the tropics where there may be more than one growing season, more than one ring may be laid down. A better rule would be "one growing season, one ring."

- **How might the history of an area help us tell how old a tree is?**

  Sometimes people can tell you when a tree or a woodlot was planted. Often trees replant themselves after a stand has been cut down or there has been a fire. Trees now growing will have started life a little after the older trees were destroyed.

- **How might size help in telling the age of trees?**

  Trees of the same species growing in similar environmental conditions will be about the same size and age. Once you know the age of one tree of a certain size, you can guess the ages of others.

DASH

Name________________________

Date________________________

STUDENT PAGE 5.4.6B THE AGE OF TREES

1. **What are the approximate ages of your trees?**

2. **Describe how you determined the age of your trees.**

ACTIVITY 5.4.7
TREES, SHRUBS, AND GRASSES

OBJECTIVES

The students
- Develop working definitions of grasses, shrubs, and trees.
- Observe how well grass grows beneath isolated shrubs and trees.
- Observe how well grass grows under thickets of shrubs and thick woodlot or forest canopies.
- Observe what kinds of plants, if any, grow beneath thickets of shrubs and thick woodlot or forest canopies.

BACKGROUND

This activity is the first of a two-part series on the study of the interaction of trees, shrubs, and grasses. It is a field survey motivated by the question of where grasses grow in relation to trees and shrubs. Experiments are developed to explain the observations about grasses in the second part, 5.4.8 GRASSES: WHY DO THEY GROW THERE?

Definitions

In most classes the students will have to find definitions for shrubs, trees, and grasses in reference books, though commonsense descriptions can be used. The terms *shrub* and *bush* are commonly used synonymously.
- *Grasses* are short plants with blade-like leaves and jointed stems.
- *Shrubs* and *bushes* are low, multibranched, woody-stemmed plants with branches attached at or near ground level.
- *Trees* are tall, woody-stemmed plants with branching usually occurring considerably above ground level.

Work Sites

Ideally the students will have access to isolated shrubs and trees in grassy areas as well as those in thickets of shrubs and woodlots or forests of trees. Isolated shrubs and trees can often be found on campuses. Hedges and clumps of ornamental shrubbery around the school will provide a place to look for grasses where the foliage canopy is thick. Finding densely wooded areas or forested areas may require field trips.

The activity is organized on the assumption that there are some grasses and shrubbery on the school campus. If this is not so, the entire activity will have to be done off campus. It can also be done as a special project for students who have access to off-campus shrubs and trees.

Grasses

Grasses usually need strong direct sunlight to grow vigorously. The students will usually find that grasses will grow under isolated trees where the sun reaches them. This is particularly true where leaves are raked. Few grasses will grow under shrubs, thickets, densely growing woodlots, or forests of trees. The students will probably find that ferns, mosses, climbing vines, and some broad-leafed flowering plants grow under forest trees.

STUDENT ROLES

Botanist
Ecologist

MATERIALS

Student Page 5.4.7 TREES, SHRUBS, AND GRASSES

PRODUCTS

Completed Student Pages

PROCEDURES

1. **Have the students create working definitions of the terms grasses, shrubs, and trees.**

   Have them
   - Develop concept maps about trees, shrubs, and grasses.
   - Go outdoors and observe trees, shrubs, and grasses.
   - Consider, size, shape, and structure.
   - Use a dictionary for additional ideas after they have made their working definitions.

2. **Introduce the investigation by asking where grasses grow in relation to shrubs and trees. Have the students share their experience.**

3. **Have the students observe where grasses grow in relation to trees and shrubs and then develop a series of questions about this relationship.**

Develop such questions as these:

- Are there differences in the amount of grass growing beneath single shrubs standing by themselves and groups of shrubs growing together?
- If any grass is found beneath single or thickets of shrubs, where does it grow? (Usually on the outer edge of the shadowed area. Tall grasses may grow up through shrubs, particularly in tropical climates.)
- If any grass is found growing under shrubs, what is the condition of the ground? Is it covered with leaf mulch?
- Do plants other than grasses grow beneath shrubs?
- If any other plants are growing beneath the shrubs, what kind of plants are they?
- If other plants grow beneath shrubs, do they grow in the same kinds of places where grasses grow?
- Are there differences in the amount of grass growing beneath single trees standing by themselves and the amount found beneath trees in woodlots or forests?
- If any grasses are growing, where under the trees do they grow?
- If any grasses are growing under trees, what is the condition of the ground?
- Do plants other than grasses grow beneath trees?
- If other plants are growing beneath trees, what kind of plants are they?
- If plants other than grass grow beneath trees, do they grow in the same kinds of places where grasses grow?
- What other questions do we have about the relationship of grasses to trees and shrubs?

4. **Organize the students to look for answers to their questions.**

- To save time, form groups of students to study shrubs and trees.
- Have the students make observations and report on their findings.
- Record all findings.

5. **Help the students summarize their observations using one or more of the four generalizations listed in Student Page 5.4.7 TREES, SHRUBS, AND GRASSES. Students' observations may either support or refute the generalizations. Proceed to Activity 5.4.8 GRASSES: WHY DO THEY GROW THERE?**

   - **Generalization 1.** Little grass is found growing in open areas where there are few trees and shrubs, but a great deal is found growing beneath shrubs. (This generalization will normally be rejected as not reflecting fact. Grasses are found in sun-drenched lawns and meadows.)

   - **Generalization 2.** Little grass is found under isolated trees, but much is found under thick canopies of trees. (Again this will not reflect fact. Grass gets a great deal of sunlight under isolated trees, but not under a forest canopy.)

   - **Generalization 3.** Much grass is found under isolated trees that have a dense covering of decaying leaves on the ground beneath them. (Again usually not true—leaves and mulch are used to keep grass from growing.)

   - **Generalization 4.** Plants other than grasses may be found under tree canopies; however, these plants usually are not found in open areas. (This is true—ferns, mosses, and broad-leaved plants that do poorly in direct sunlight often cover a forest floor.)

EXTENSION

- Have the students take photographs to record their field work.

DASH

Name

Date

STUDENT PAGE 5.4.7 TREES, SHRUBS, AND GRASSES

1. Record your working definitions of trees, shrubs, and grasses.

   Trees

   Shrubs

   Grasses

2. Record the questions about trees, shrubs, and grasses you are investigating.

Name______________________________

3. Record the observations you made in seeking answers to your questions.

4. From all class observations which, if any, of the following generalizations would seem to be correct. Put an *(X)* in front of each correct generalization.

	Generalization 1. Little grass is found growing in open areas where there are few trees and shrubs, but a great deal is found growing beneath shrubs.
	Generalization 2. Little grass is found under isolated trees, but much is found under thick canopies of trees.
	Generalization 3. Much grass is found under isolated trees that have a dense covering of decaying leaves on the ground beneath it.
	Generalization 4. Plants other than grasses may be found under tree canopies; however, these plants usually are not found in open areas.

ACTIVITY 5.4.8 GRASSES: WHY DO THEY GROW THERE?

OBJECTIVES

The students
- Make generalizations about grasses, shrubs, and trees.
- Develop hypotheses to explain one or more of the generalizations.
- Design experiments to test their hypotheses.
- Carry out their experiments.
- Interpret their data.
- Report their findings.
- Review the nature of a single-variable experiment.

BACKGROUND

This is the second in a series of two activities that look at some conditions necessary for common grasses to grow. The first in the series is Activity 5.4.7 TREES, SHRUBS, AND GRASSES. In GRASSES: WHY DO THEY GROW THERE? the students first go through a hypothetical experimental situation with radish seeds. After this mental exercise, they then develop their own experiments using grass seed to search for an explanation to account for where plants grow. They develop explanatory hypotheses and test them. This activity provides an opportunity to begin thinking about appropriate experimental methodology—controls, experimental setups, single variables, adequate population sizes, and so forth. Where possible the students should take the lead in report sessions.

Observations

Most grasses need direct sunlight to grow and thrive. There are other factors that also affect their growth. Usually from their survey of grasses, shrubs, and trees in Activity 5.4.7 GRASSES, SHRUBS, AND TREES the students will have found that grass grows well in the open and under isolated trees, but little (if any) grass grows under shrubs or dense woodlots or forests. They will usually have found that ferns, mosses, vines, and some broad-leafed flowering plants do grow well under shrub and forest canopies. They also will usually have found that grasses do not seem to grow well where there is a buildup of decaying leaves.

Generalizations

These observations may be summarized in a set of four generalizations of what was most likely to have been observed. The students' observations may not agree with these, making the experiments all the richer. See Student Page 5.4.7 TREES, SHRUBS, AND GRASSES.

- **Generalization 1.** Little grass is found growing in open areas where there are few trees and shrubs, but a great deal is found growing beneath shrubs. *(Normally false.)*
- **Generalization 2.** Little grass is found under isolated trees, but much is found under thick canopies of trees. *(Normally false.)*
- **Generalization 3.** Much grass is found under isolated trees that have a dense covering of decaying leaves on the ground beneath it. *(Normally false.)*
- **Generalization 4.** Plants other than grasses may be found under tree canopies; however, these plants usually are not found in open areas. *(Normally true.)*

Inquiry

A series of hypotheses can be formed to explain rejection or support of a generalization. Don't expect every student to have an experiment that works out as predicted. This would give a false impression of the nature of science inquiry. The students should be helped to recognize that a failed hypothesis is as important in giving direction to science as a successful one. What is important here is that the students have practice in the processes of hypothesis formation and testing and conclusion drawing. The hypotheses listed are only a selective sample of what may to be offered by students.

Possible Hypotheses for Meager Grass Growth

The following are some hypotheses that might be suggested to explain the lack of grass beneath shrubs and trees:

- Shrubs and trees keep water from entering the ground so grass cannot get enough to grow.
- Shrub and tree leaves accumulate on the ground beneath them so grass cannot grow.
- Shrub and trees keep out the light so that grass cannot grow.

Possible Hypotheses for Growth under Canopies

Below are some hypotheses that might be suggested to explain the growth of plants beneath dense canopies:

- Plants that grow well beneath tree canopies require less water than grasses.

- Leaf materials are helpful to plants that can grow well beneath tree canopies.
- Plants that grow well beneath tree canopies do not need as much light as grasses.

There are numerous other hypotheses that might be advanced.

Experimental Design

Generalizations lead to questions about how we account for them. The questions to focus experiments on here should use a basic single-variable design. The *variable* is the condition or thing that is being changed. The students will need to have two sets of test samples:

- One sample, called the *control sample*, that will be exposed to all the conditions that are normally present in the working or living environment. In the case of a plant these would be normal exposure to water, light, soil, air, temperature, and so forth.
- Another sample, called the *experimental sample*, that will be exposed to the same conditions the control is exposed to except one, the variable.

Suggested Equipment

Help the students make growing chambers. This can be done by punching holes in the bottom of pint milk cartons and filling them with moist dirt. The chambers can be placed in trays to catch draining water. It is suggested that at least three chambers be used for each sample. Three samples are usually used in an experiment so that if the results are different in any two chambers, the third chamber can indicate which results are more likely. A practical consideration will be space. It is possible to get multiple samples by having more than one group working with the same design.

Number of Seeds

Ten seeds or plants are suggested for each chamber. This number gives a direct conversion to percentage. If the students are studying established plants rather than growth from seed, put more than ten seeds in a carton. Allow them to grow and become established then selectively thin the crop to ten plants.

Some Specific Experimental Designs

To give a sense of the experimental process several hypotheses and illustrative designs are described. These need not be the ones the students use.

Hypothesis A. Shrubs and trees keep water from entering the ground so grass cannot get enough water to grow.

Possible design to test restricted water hypothesis:

- Put cartons under shrubs and in a grassy area. Measure the amount of water in each carton after a rain or measure the amount of water in each carton after it has been sprinkled by a lawn sprinkler.
- If the amounts are different, calculate the fraction of the water that falls on the grass and reaches the ground beneath the shrubs.
- Each time that it rains or the lawn and shrubs are watered give the experimental samples their water fraction.
- Give both samples equal amounts of light and keep them at the same temperature.

Hypothesis B. Shrubs and trees have leaves that accumulate so grass does not grow well.

Possible design to test leaf mulch hypothesis:

- Grow two separate samples of seeds—the experimental sample under a mixture of leaf material on the soil and the control sample in plain soil. Have the same number of seeds evenly spaced in each carton.
- Give both samples equal amounts of light and water and keep them at the same temperature.

Hypothesis C. Shrubs keep out the light so that grass cannot grow well.

Possible design of light hypothesis:

- Grow an equal number of grass seeds in cartons that receive equal amounts of water at the same temperature. Place the control sample in full sunlight and the experimental sample in the deep shade. To achieve shade, cover one carton with several layers of screening so air can still get in.

The students should be encouraged to come up with their own designs. Use the listed designs only if needed.

Interpretation of Data

As experiments are completed, the students should check their original hypotheses against their data. Problems should be noted and judgment should be made as to whether the hypotheses might be correct.

The students should be introduced to the idea that no single successful experiment is proof of a hypothesis. In fact, a hypothesis is always open to retesting. A hypothesis may work with some tests but not with others. When a hypothesis never works, it can be assumed that the hypothesis is totally or partly wrong or there is a flaw in the experiment.

Working Groups

Depending on the class, work space, and equipment, work groups should normally be from 2 to 4 students. It may be helpful to have more than one group working on the same hypothesis.

Comments

Set the tone of the experimentation by pointing out from the beginning that the students may need to run their experiment several times. Fortunately, grass seeds grow quickly.

Though the designs are quite straightforward, the results may be less than clean. This is the nature of experimentation. It can be expected that some of the grass deprived of water or sunlight will grow, but it normally will not *flourish*. In addition to the number of seeds growing, evidence of the plants' health or condition should be looked at.

There are many factors that contribute to where different plants grow. Generally grasses need direct sunlight and are inhibited by mulch. Ferns, moss, and broad-leafed climbing and ground plants need less light and the moist, humid environment of the forest.

STUDENT ROLE

Botanist

MATERIALS

pint milk cartons
tin cans for rain gauge
trays to hold cartons
lawn grass seed
screening
soil
watering devices
Student Page 5.4.8 GRASSES EXPERIMENT

PRODUCTS

Experiment
Completed Student Pages

PROCEDURES

1. **Introduce a model of a single-variable experiment. Have the students work in small groups to design a hypothetical experiment to test the hypothesis that radish seeds will germinate better in soil at room temperature than in soil at a refrigerator temperature of 5° to 6°C.**

2. **Introduce or review the techniques of experimentation in discussing the students' designs.**

   Ask such questions as these:
   - What do we mean by the term hypothesis? (Get at the idea that a *hypothesis* is a suggested explanation, a guess as to why something happens.)
   - What do we mean by experiment? (Get at the idea that an *experiment* is a way of testing to see whether an idea may be correct.)
   - What do we mean by *experimental design?* (Get at the idea of a plan for carrying out an experiment.)
   - What is our hypothesis about refrigeration? (Have students restate the hypothesis.)
   - What seeds are we talking about? (Work to the idea that as the hypothesis is stated, we are talking about all radish seeds.)
   - What seeds shall we use to test? (Get their suggestion.)
   - What do we mean by *germinate?* (Work to the idea of beginning to grow or just pushing through the soil.)
   - What do we mean by "better," as in "will germinate better"? (Work to such ideas as more seeds pushing through the soil or seeds coming through the soil faster.)
   - How can we get the temperature around a sample to match that found in a refrigerator? (Putting things in a refrigerator or putting things outside in cold weather during winter could lower the temperature. Point out that this sample is called the *experimental sample* because it is the one we are experimenting with.)

- How can we get soil temperature to room temperature? (Leave it in the room. Point out that this sample of seed is called the *control sample.* It is growing under normal conditions.)
- What can we grow the seeds in? Should we use different types of containers for the near-freezing soil and the room temperature soil? Why? (Work to the idea that all containers should be the same so that we know what effect the single-condition or *variable* (temperature) is responsible for. Milk cartons are convenient containers.)
- What other things should be the same? (List such things as the amount of water, the amount of soil, and the amount of light.)
- How could we adjust for light? (Work to the idea of using artificial light if done in a refrigerator, natural light if done outdoors.)
- How many containers of each sample of seeds would you need to have? (Work to the idea that you would need at least 3 containers If there is a difference in the results of 2 containers, the third can indicate which of the two results is the more likely.)
- How many seeds would you need? (Work to the idea that seeds are like us—some of us grow up quickly while some grow slowly. Some seeds may be defective and not grow at all. We are trying to get a picture of average seeds; therefore, we have to look at many seeds so that we can see what most seeds do. Ten is a good starting number because we can get percentage simply by counting. If one seed grows, we have 10% of the seeds; if 2 seeds grow, we have 20% of the seeds, and so forth.)

3. **Describe a hypothetical experiment to test the hypothesis that temperature affects the germination of red radish seeds. Tell the students that 10 radish seeds were to be planted in each of 6 growing cans. Three of the cans were to be set in a refrigerator and 3 were to be kept in a drawer at room temperature. There was to be no light in either the refrigerator or the drawer.**

4. **Give the students the results of such an experiment and help them analyze the data. See Table 5.4.8.**

Table 5.4.8 Running total of seeds germinated

Days	*Experimental Sample* Refrigerator: 30 Seeds	*Control Sample* Warm Drawer: 30 Seeds
1	0	0
2	0	0
3	0	9
4	0	15
5	0	23
6	3	24

Ask such questions as these:

- What percentage of the refrigerated seeds, the experimental sample, germinated? (Three out of 30 or 10%.)
- What percentage of the room temperature seeds, the control sample, germinated? (Twenty-four out of 30 or 80%.)
- What might have happened if the experiment had been continued one more day? (Probe for the idea that more seeds might have germinated.)
- Which of these two samples of seeds germinated better? (Work to the idea that the seeds at room temperature germinated better where "better" means more completely in the time of the experiment and where "better" means much faster.)
- Is the original hypothesis that radishes grow better at room temperature supported? (Work to the idea that it certainly holds for this experiment with this type of radish when "better" is defined as germinating more completely and quicker.)
- What would you want to do before you were sure of your interpretation about this type of radish? (Lead the students to the idea that the experiment should be run again just to be sure that no mistakes were made.)
- If you ran the experiment again and had similar results, could you say that the hypothesis would always be correct? (Work to the idea that we can be sure only about the radishes we have tested. However, since the hypothesis works here, it has a good chance of working with other radish seeds. We can't be sure about all seeds, but we can be quite sure about this type of radish seeds if they are germinated under similar conditions.)

5. **Help the students review their field study of grasses, shrubs, and trees. Discuss the generalizations about where grass, shrubs, trees, and other plants grow together.**

- **Generalization 1.** Little grass is found growing in open areas where there are few trees and shrubs, but a great deal is found growing beneath shrubs.
- **Generalization 2.** Little grass is found under isolated trees, but much is found under thick canopies of trees.
- **Generalization 3.** Much grass is found under isolated trees that have a dense covering of decaying leaves on the ground beneath it.
- **Generalization 4.** Plants other than grasses may be found under tree canopies; however, these plants usually are not found in open areas.

6. **Have the students suggest hypotheses to explain one or more of the generalizations found in the observation of the interaction of grasses, shrubs, and trees.**

7. **Have the students design experiments to test one of more of the hypotheses.**

8. **Have the students report on their designs and have a class discussion leading to redesign where necessary.**

   Help the students include the following:
   - Their statement of their hypotheses.
   - Definitions of terms.
   - Their equipment.
   - The number of seeds to be tested.
   - Provision for an experimental setup with a control and a single variable.
   - What data are being collected.
   - Provision for care over weekends.

9. **Have the students collect, make, and assemble their equipment and carry out their experiment.**

10. **Have the students interpret their data.**

11. **Have the students report on their findings.**

Have them include their
- Hypothesis statement.
- Definitions of terms.
- Description of their equipment.
- Description of their control and experimental setup.
- Data.
- Their interpretation of their data.

12. **Have the students discuss the question of what seems to account for why grasses grow where they do.**

EXTENSIONS

- Encourage the students to set up plant experiments at home.
- Have the students seek out a forester or other expert and ask about the ecology of plant populations in forests.

DASH

Name______________________

Date______________________

STUDENT PAGE 5.4.8 GRASSES EXPERIMENT

1. State one generalization about the interaction of grasses, shrubs, and trees that you want to study.

2. Suggest hypotheses to explain the generalization about the interaction of grasses with shrubs or trees.

3. Give a working definition of the following terms:

   Variable

Name________________________________

Control

Experimental Sample

4. Describe an experimental design to test your hypothesis. Include
   - a statement of your hypothesis
   - definitions of terms you will be using
   - description of your equipment
   - the number of organisms to be tested
   - provision for care over weekends

Name________________________________

5. Attach any data sheets used for your experiment.

6. Write a report on your experiment. Be sure to include the following:
   - a statement of your hypothesis
   - definitions of the terms you used
   - description of your equipment
   - description of your control and experimental setup
   - your data
   - your interpretation of your data

ACTIVITY 5.4.9 ROOTS

OBJECTIVES

The students
- Observe that different types of plants have roots that go to different depths.
- Observe that some plants that have tap roots and others have fibrous roots.
- Observe the soil-holding properties of roots.

BACKGROUND

This activity is a continuation of DASH soil and plant studies begun in grade 2. Here the focus is on the depth of root penetration into the soil, the spreading out of roots in the soil, and the soil-holding properties of roots. This is an invention activity in which the students devise their own method of finding answers.

Roots

Water and dissolved minerals needed by green land plants are usually absorbed or taken in through the plants' root systems. Among the trees, shrubs, grasses, and other flowering plants there are two common types of root systems, fibrous and taproot.

Fibrous Root Systems

Fibrous root systems are made up of a few to many main roots. Usually there are many side roots that originate at the base of the stem. Fibrous root systems are characteristic of grasses and many shrubs.

Tap Root Systems

Tap root systems have a large primary root with branches of smaller secondary roots. This type of system is characteristic of most trees and root crops such as carrots and beets.

Field Work

A site is needed where there is a stand of grass and weeds that can be dug up. The plants should be 5–10 cm tall. Usually the dimensions of a plant above and below ground will be about the same. However, the root systems of some plants may be much larger than their leaf systems above ground. Plants much taller than 10 cm may have roots not easily reached with a shovel.

- Demonstrate how to dig up a plant to get all the roots.
- Demonstrate how to break the clod to return the soil to the hole from which it was taken.
- If water is used to remove the soil from roots, have the students invent a way to retrieve the soil and return it to the hole.

Root System Estimates

Estimates of the total length of roots on a fibrous-root and a tap-root plant are undertaken to give a sense of magnitude. Precision is not possible with the equipment available. However, the students can begin to appreciate how very long root systems are. Measuring some systems will help the students better understand how roots hold soil in the face of erosional forces.

STUDENT ROLE

Botanist

MATERIALS

hand lenses
shovel
meter tape or rule
hose
newspaper
garden scissors
Student Page 5.4.9 ROOTS

PRODUCTS

Completed Student Pages

PROCEDURES

1. **Present the problem of finding out how extensive the root system of grasses and weeds are.**

   Help the students with such questions as these:
   - How can we find out how deep roots penetrate into the soil?
   - How can we find out how far roots spread laterally? (Lead them to the idea of digging up a plant.)
   - How can we remove soil from the roots? (Work to the idea of shaking soil out of the roots or washing it away.)

2. **Have the students work in small groups to dig up different kinds of small plants, remove dirt from their roots, and observe them. Use plants 5–10 cm high.**

   Have the students record the following:
   - The shape of the plant, including roots, stem, and a leaf drawing.
   - The length of the longest root(s).
   - The total length of the secondary roots attached to the longest main root.
   - The average length of hair roots. (Very fine secondary roots.)
   - An estimate of the total length of all the roots on their plant.
   - The height of the stem and leaves above ground.

3. **Have the students observe the roots with a hand lens and record their findings on Student Page 5.4.9 ROOTS.**

4. **Review the students' observations.**

   Ask such questions as these:
   - When you dug up the roots of plants, what did you find attached to them?
   - Were there some plants with more soil attached than others? Which ones?
   - What kinds of roots seem to hold the most soil? (These normally will be those of the grasses or other fibrous-root plants.)
   - What kinds of roots seem to hold soil at the greatest depth? (These will normally be plants with tap roots.)
   - What kinds of roots will hold tiny stones? (Tiny stones will often cling to the very fine roots of plants.)
   - On tap-root plants, what were your estimates of the total length of all the roots on the main root? (Record these lengths. They may be over a meter.)
   - On tap-root plants, what were your estimates of the total length of all the roots? (The total length may be several meters.)
   - On fibrous-root plants, what were your estimates of the total length of all the roots you measured? (Record these lengths.)
   - On fibrous-root plants, what were your estimates of the total length of all of the roots? (The total length may be several meters.)
   - Which kind of plants seemed to have the longer root systems, fibrous or tap-root plants? (Normally fibrous-root plants of the

same height as tap-root plants will have the longer total root system.)

- What advantage could fibrous-root plants have over tap-root plants? (Work to the idea that they have more root area to absorb water and minerals.)
- What advantage could tap-root plants have over fibrous-root plants? (Work to the idea that they may go deeper for water and minerals.)

EXTENSION

- Have the students start a root watch and report on the root systems of trees and other plants.

DASH

Name________________________

Date_________________________

STUDENT PAGE 5.4.9 ROOTS

1. Draw the shape of the roots, stems, and leaves of each type of plant you have observed. Show height and width in centimeters.

2. Record your data below.

Tap-Root Plant

- length of the longest root(s) ________________
- total length of secondary roots attached to the longest main root ________________
- estimate of the total length of all the roots on your plant ________________

Fibrous-Root Plant

- length of the longest root(s) ________________
- total length of the roots attached to the longest main root ________________
- estimate of the total number of fibrous main roots ________________
- estimate of the total length of all the roots on your plant ________________

Name ______________________________

Hair Roots

- length of a root hair ______________
- estimate of number of root hairs on a fibrous root ______________
- estimate of number of root hairs on a secondary root of a tap root ______________

3. Explain how you made your estimates.

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4. Describe what you saw when you observed the roots with a hand lens.

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5. When you dug up the roots of plants, was anything attached to the roots? If so, what was it? ______________

6. What kind of plants seemed to have the longest root system, those of fibrous- or tap-root plants?

____

Name______________________________

7. What advantage could fibrous-root plants have over tap-root plants?

8. What advantage could tap-root plants have over fibrous-root plants?

ACTIVITY 5.4.10 SOIL CONSERVATION

OBJECTIVES

The students

- Observe soil in a stream table subjected to simulated rain.
- Simulate soil conservation procedures in a stream table.
- Test soil conservation simulations.

BACKGROUND

This activity focuses on study of roots, natural ground covering, and techniques used in agriculture and industrial landscaping to conserve top soil. The students begin by making a stream table and observing the runoff of soil and water in simulated rain. They then use a conservation procedure to minimize runoff on the stream table.

Stream Table

A stream table can be made from a cardboard frame covered with a plastic garbage bag. The frame is filled with soil, and the bottom of the bag is shaped into a funnel to make the soil and water flow into a bucket or plastic-covered box. See Figure 5.4.10. Tables can be modified and turned into living conservation landscapes by planting and watering them.

Forest Ground Covering

Leaves and small fragments of rotten wood can be left on a soil-covered frame for several weeks. If kept moist, they will rot and produce a forest-like ground covering.

Grassy Slope

Grasses can be planted on a soil-covered frame to simulate a grassy slope. The grass will need abundant sunlight and about a week and a half to grow.

Weedy Slope

Birdseed can be planted on a soil-covered frame to simulate a weed-covered slope. Again, the plants will need sunlight and a week and a half to grow.

STUDENT ROLES

Agronomist
Soil conservation manager
Farmer
Forest manager

MATERIALS

soda-can box or other cardboard box for frame
heavy-duty garbage bags
bucket or strong cardboard box lined with plastic
soil
birdseed
small rocks for terracing
gallon can or other device to simulate rain
nails
hammers
large protractor
Student Page 5.4.10 SOIL CONSERVATION

PRODUCTS

Soil conservation models
Completed Student Pages

PROCEDURES

1. **Have the students make a stream table.**

   Have them
   - Place a plastic garbage bag over a shallow cardboard frame.
   - Fill the frame with soil.
   - Build a plastic spillway to carry any soil and water runoff into a bucket or other container.
   - Elevate the table to an angle of about 20°.
   - Make a rain simulator from a gallon can by putting 8 to 10 nail holes in the base. (A hose with a fine spray can also be used.)

2. **Have the students inspect their construction and predict what will happen when they use their rain simulator to water the upper end of the table for a period of 5 minutes. Have them refill the rain simulator as needed.**

Ask such questions as these:
- What effect will the water have on the soil at the upper end?
- What effect will the water have on the soil at the dry end?
- What will be found in the bucket?

3. **Have the students investigate the effects of water on the soil.**

Summarize with such questions as these:
- What effect did the water have on the soil at the upper wet end?
- What effect did the water have on the soil at the dry end?
- What was found in the bucket?
- Have you ever seen situations in the natural environment where erosion like this has taken place?
- What helps prevent such erosion in the natural environment? (Help the students recall the function of grasses and their root structure and the covering of forest floors by a blanket of decaying matter.)
- How do farmers help prevent erosion? (Get at such things as practicing contour farming, planting pastures, using terraces.)
- What other methods can be used to prevent erosion? (Work to such ideas as channeling runoff into sewers, building dams, covering areas with concrete.)
- Why would we want to prevent erosion?

4. **Introduce the erosion prevention project. Give the students a week and a half to use plants and other conservation techniques to stop or greatly reduce erosion on a stream table.**

Help them consider the following:
- Grass. (It will take several weeks for a good covering of grass to grow on a stream table.)
- Decayed-leaf and twig covering.
- Contour-plowed soil.
- Terraced areas.
- A storm-drain system.
- Other suggestions.

5. **Have the students test their stream tables as before and report on their findings.**

Ask such questions as these:
- Which of the techniques produced the least soil runoff? Why?
- How do grass covered and decayed leaf surfaces compare in preventing erosion?
- What techniques work best for farming?
- Why is erosion control important?

EXTENSION

- Invite a county agricultural agent or a forester to talk on soil conservation.

ILLUSTRATION

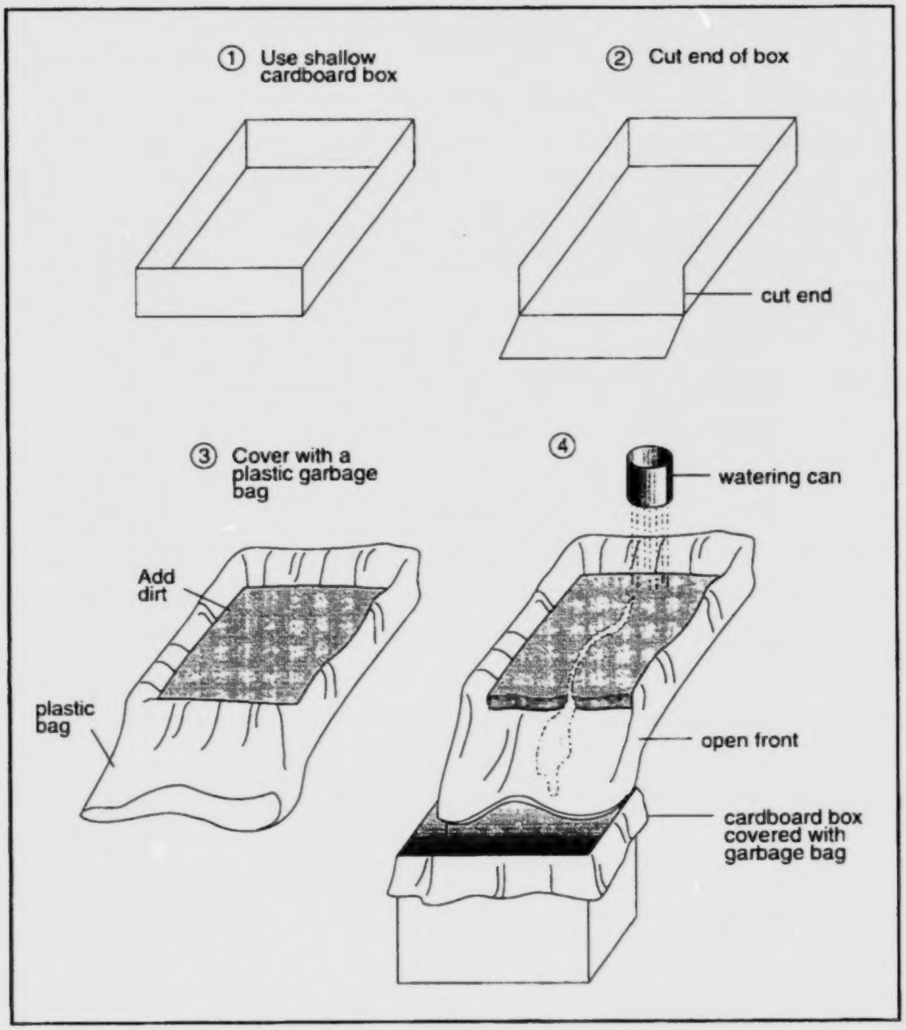

① Use shallow cardboard box
② Cut end of box
cut end
③ Cover with a plastic garbage bag
Add dirt
plastic bag
④
watering can
open front
cardboard box covered with garbage bag

Figure 5.4.10 A stream table

Name________________________

Date________________________

STUDENT PAGE 5.4.10 SOIL CONSERVATION

1. Draw the stream table before and after the soil is “rained” on.

2. Describe what happened to the soil in the stream table.

Name____________________________

3. Make a diagram showing the technique you intend to use to prevent soil erosion. Explain why you think it will work.

4. Describe what happened to the soil in the stream table after conservation measures had been taken.

5. Explain why conservation of soil is important.

Name____________________

Date____________________

STUDENT PAGE 5.4.1
ANNUAL, BIENNIAL, AND PERENNIAL PLANT PROJECT

1. Record the question you have decided to research.

2. Name the garden plant you selected and tell why you selected it.

3. Describe your experimental design.

Name________________________________

4. Describe how you carried out your experiment.

5. Discuss your findings.

6. Record your working definition for the term *annual.*

7. Record your working definition for the term *biennial.*

8. Record your working definition for the term *perennial.*

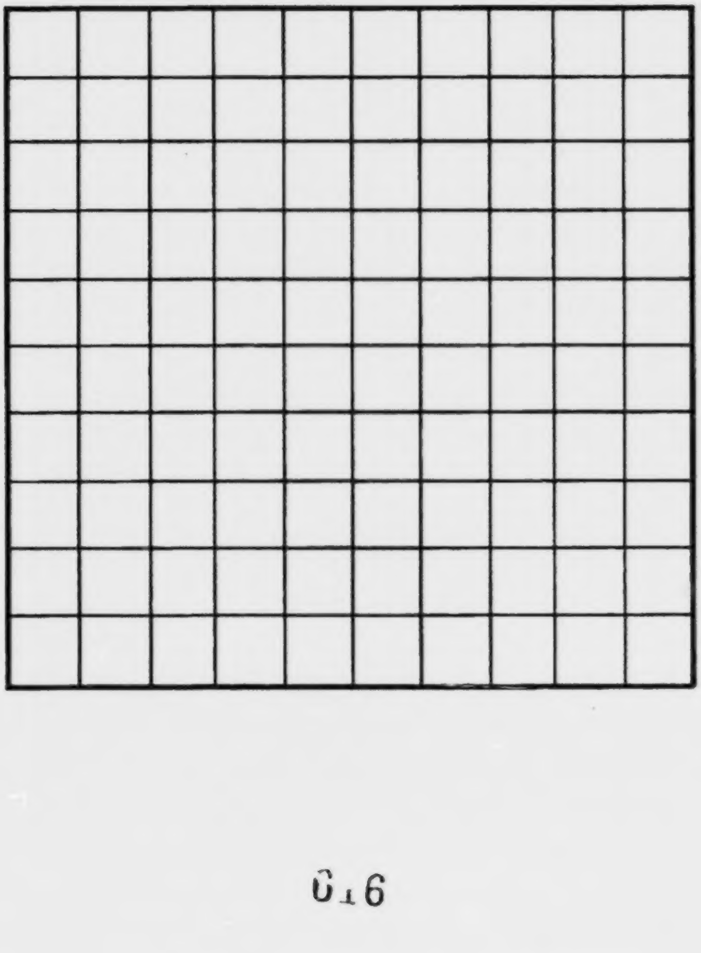
DASH

Name____________________________

Date____________________________

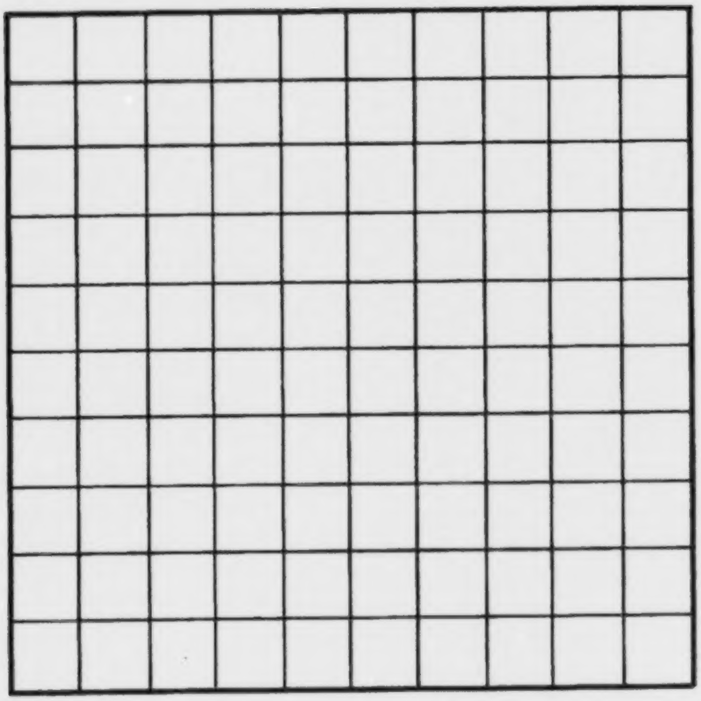
STUDENT PAGE 5.4.2 TREE HARVESTING

1. Graph the tree's change in height since it was planted.



Name______________________________

2. **Graph the tree's change in circumference since it was planted.**



3. **Explain how you measured the area of the shadow pictures of the tree.**

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Name______________________________

4. Show your calculations of the amount of increase in circumference that took place for each meter increase in height.

5. Show your calculations of the amount of increase in height that took place compared to increase in the shadow area. Measure the shadow in squares 10 cm on a side.

6. Draw the rings of the tree the same size as they appear in the cutting.

Name____________________________

7. How does the age of the tree seem to relate to the number of rings?

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8. How does the weather seem to have affected the growth of the tree's annual rings?

____

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DASH

Name________________________

Date________________________

STUDENT PAGE 5.4.3 TREE PLANTING

1. Explain why we replant after trees after we harvest them.

2. Explain why each generation must consider the needs of generations to come as we deal with our environment.

DASH

Name__________________________

Date___________________________

STUDENT PAGE 5.4.4 OBSERVING TREES

1. **Draw maps to show the locations of the trees you selected for observation so that someone else can find them.**

2. **Sketch the shape of your trees, taking care to show their approximate proportions.**

Name____________________

3. Describe the covering on the ground beneath your trees.

4. Describe other trees and plants that are near your trees.

5. Measure and record the circumference of your trees.

6. Measure and record the height of your trees. Tell how you made the measurements.

Name____________________

7. **Describe the animals that use the trees. Include**
   - **birds that eat the fruit or seed**
   - **birds that nest or roost in the trees**
   - **insects that use the trees for food**
   - **insects that lay their eggs in the trees**
   - **other animals living in or under the trees**

8. **What economic value, if any, do these trees have? Explain.**

9. **In what ways do broad-leafed trees differ from conifers?**

DASH

Name ______________________

Date ______________________

STUDENT PAGE 5.4.5 MEASURING TREES

1. Record the height of your trees and describe the method you used to arrive at the figures.

2. Record the circumferences of your trees' trunks.

3. Record the foliage circumferences of your trees and describe the method you used to arrive at the figures.

DASH

Name________________________

Date________________________

STUDENT PAGE 5.4.6A DETERMINING THE AGE OF TREES

- **How might growth rings tell us the age of a tree?**

  When a tree is cut, you may be able to see a series of rings like those in a target. Each ring represents a growing season. For most trees this will also represent a year's growth. In temperate zones the number of rings usually equals the age of the tree in years.

- **When might the rule "one ring, one year" not be true?**

  In places such as the tropics where there may be more than one growing season, more than one ring may be laid down. A better rule would be "one growing season, one ring."

- **How might the history of an area help us tell how old a tree is?**

  Sometimes people can tell you when a tree or a woodlot was planted. Often trees replant themselves after a stand has been cut down or there has been a fire. Trees now growing will have started life a little after the older trees were destroyed.

- **How might size help in telling the age of trees?**

  Trees of the same species growing in similar environmental conditions will be about the same size and age. Once you know the age of one tree of a certain size, you can guess the ages of others.

DASH

Name______________________

Date______________________

STUDENT PAGE 5.4.6B THE AGE OF TREES

1. What are the approximate ages of your trees?

2. Describe how you determined the age of your trees.

DASH

Name________________________

Date________________________

STUDENT PAGE 5.4.7 TREES, SHRUBS, AND GRASSES

1. Record your working definitions of trees, shrubs, and grasses.

Trees

Shrubs

Grasses

2. Record the questions about trees, shrubs, and grasses you are investigating.

Name______________________________

3. **Record the observations you made in seeking answers to your questions.**

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4. **From all class observations which, if any, of the following generalizations would seem to be correct. Put an *(X)* in front of each correct generalization.**

	Generalization 1. **Little grass is found growing in open areas where there are few trees and shrubs, but a great deal is found growing beneath shrubs.**
	Generalization 2. **Little grass is found under isolated trees, but much is found under thick canopies of trees.**
	Generalization 3. **Much grass is found under isolated trees that have a dense covering of decaying leaves on the ground beneath it.**
	Generalization 4. **Plants other than grasses may be found under tree canopies; however, these plants usually are not found in open areas.**

DASH

Name________________________

Date________________________

STUDENT PAGE 5.4.8 GRASSES EXPERIMENT

1. State one generalization about the interaction of grasses, shrubs, and trees that you want to study.

2. Suggest hypotheses to explain the generalization about the interaction of grasses with shrubs or trees.

3. Give a working definition of the following terms:

   Variable

Name______________________________

Control

Experimental Sample

4. **Describe an experimental design to test your hypothesis. Include**
   - **a statement of your hypothesis**
   - **definitions of terms you will be using**
   - **description of your equipment**
   - **the number of organisms to be tested**
   - **provision for care over weekends**

Name________________________________

5. Attach any data sheets used for your experiment.

6. Write a report on your experiment. Be sure to include the following:
   - a statement of your hypothesis
   - definitions of the terms you used
   - description of your equipment
   - description of your control and experimental setup
   - your data
   - your interpretation of your data

Name ______________________

DASH

Date ______________________

STUDENT PAGE 5.4.9 ROOTS

1. Draw the shape of the roots, stems, and leaves of each type of plant you have observed. Show height and width in centimeters.

2. Record your data below.

Tap-Root Plant

- length of the longest root(s) ______________
- total length of secondary roots attached to the longest main root ______________
- estimate of the total length of all the roots on your plant ______________

Fibrous-Root Plant

- length of the longest root(s) ______________
- total length of the roots attached to the longest main root ______________
- estimate of the total number of fibrous main roots ______________
- estimate of the total length of all the roots on your plant ______________

Name ______________________________

Hair Roots

- length of a root hair ____________
- estimate of number of root hairs on a fibrous root ____________
- estimate of number of root hairs on a secondary root of a tap root ____________

3. Explain how you made your estimates.

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4. Describe what you saw when you observed the roots with a hand lens.

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5. When you dug up the roots of plants, was anything attached to the roots? If so, what was it? ____________

6. What kind of plants seemed to have the longest root system, those of fibrous- or tap-root plants?

____

Name______________________________

7. **What advantage could fibrous-root plants have over tap-root plants?**

____

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8. **What advantage could tap-root plants have over fibrous-root plants?**

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DASH

Name________________________

Date________________________

STUDENT PAGE 5.4.10 SOIL CONSERVATION

1. Draw the stream table before and after the soil is "rained" on.

2. Describe what happened to the soil in the stream table.

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Name______________________________

3. Make a diagram showing the technique you intend to use to prevent soil erosion. Explain why you think it will work.

4. Describe what happened to the soil in the stream table after conservation measures had been taken.

5. Explain why conservation of soil is important.

DASH

GRADE FIVE
CLUSTER 5

Food and Nutrition

5.5.1 Nutrients
5.5.2 Nutrients and Cells
5.5.3 Food Labeling

ACTIVITY 5.5.1 NUTRIENTS

OBJECTIVES

The students
- Review the concept of nutrients.
- Assemble and play a game to reinforce their knowledge of nutrients and their functions.
- Play a game to reinforce their knowledge of nutrients and the groups of the Food Guide Pyramid.

BACKGROUND

This activity is one of a series on nutrients and their functions in the body and is a continuation of the nutrition theme begun in kindergarten. It should precede 5.5.2 NUTRIENTS AND CELLS. NUTRIENTS is designed to refresh the students' background on nutrients by assembling and playing two games. As the students assemble the game cards, they get a preview of the listed functions and nutrients in each Food Group.

Game Cards

Three sets of cards are needed to play the games:

NUTRIENT CARDS with a *nutrient name* on the face and a listing of the major functions of that nutrient on the back

FUNCTION CARDS with a *single nutrient function* on the face and a blank back

FOOD CARDS with a *Food Group* on the face and the principal nutrients found in foods in that Food Group listed on the back

Card Construction

NUTRIENT CARDS and FOOD GROUP CARDS are made by cutting along the black lines of the sheets of the Master Sets and folding them along the dotted lines. The cards may be taped shut.

For each deck of 48 cards you will need

4	copies of	Master Set **A** NUTRIENT CARDS (There are 8 Water Cards)
1	copy of	Master Set **B** FUNCTION CARDS
3	copies of	Master Set **C** FOOD GROUP CARDS

Multiple Rounds

For full effect the students should play the games several times. The first round of each game will introduce information that may be only vaguely remembered or that may not have been confronted before. Each round will make the students more aware of nutrients and foods.

Nutrients in Foods

Raw foods have a small quantity of all nutrients because they are made of cells, and cells must have all the nutrients to function. However, the abundant supplies of the nutrients needed to fill our body's daily nutritional requirements are found in a more limited number of foods. Only foods that are found to have a relatively large supply of nutrients are listed in the Food Guide Pyramid and on the backs of the FOOD GROUP CARDS. Responses asked for in Student Page 5.5.1C NUTRIENTS AND THEIR FUNCTIONS are shown in the table below.

Table 5.5.1 Nutrients and their functions

1.	IRON	Helps carry oxygen in our body.
2.	WATER	Carries waste from the body in urine and sweat.
3.	CALCIUM	Helps in blood clotting.
4.	VITAMIN C	Helps heal burns and other wounds.
5.	PHOSPHORUS	Is the second most abundant mineral in our body.
6.	IRON	Gives blood its red color.
7.	FATS	Dissolve and carry Vitamins A, D, E, and K.
8.	PHOSPHORUS	Helps start muscle contractions.
9.	VITAMIN B COMPLEX	Helps maintain our nervous system.
10	WATER	Helps dissolve all materials carried by the blood.
11.	CALCIUM	Is the chief mineral in bones and teeth.
12.	VITAMIN A	Helps in growth of our body tissue.
13.	IRON	Is stored in the liver.
14.	VITAMIN A	Is an essential chemical in night vision.
15.	VITAMIN B COMPLEX	Helps in digestion of carbohydrates.

16.	VITAMIN D	Is a product of the body's exposure to sunlight.
17.	VITAMIN A	Helps protect mouth, nose, throat, and lung tissue from infection.
18.	VITAMIN B COMPLEX	Helps maintain healthy skin, hair, and eyes.
19.	CALCIUM	Makes up about 3% of our body weight.
20.	VITAMIN C	Helps maintain connective tissue—fat, cartilage, tendons, and bones.
21.	PHOSPHORUS	Makes up about 1% of our body weight.
22.	IRON	Helps in the use of proteins.
23.	VITAMIN B COMPLEX	Helps maintain our muscles
24.	VITAMIN C	Helps prevent oxidation of other vitamins.
25.	CARBOHYDRATES	Are changed to fat for storage.
26.	VITAMIN D	Helps in use of calcium.
27.	VITAMIN A	Helps repair our body tissue.
28.	VITAMIN C	Helps prevent viral and bacterial infection.
29.	CARBOHYDRATES	Are the chief source of our body's energy.
30.	PHOSPHORUS	Helps in energy storage.
31.	PROTEINS	Build enzymes that regulate our body.
32.	VITAMIN D	Helps in use of phosphorus.
33.	CARBOHYDRATES	Provide roughage (indigestible fiber) to aid digestion.
34.	FATS	Are the most concentrated source of energy in our body.
35.	FATS	Insulate our body from heat loss.
36.	CARBOHYDRATES	Make up about 2% of our body weight.
37.	PROTEINS	Are the chief body-building material.
38.	WATER	Makes up about 65% of our body weight.
39.	PROTEINS	Make up about 14% of our body weight.
40.	FATS	Cover and protect vital organs.

41.	PROTEINS	Are a reserve source of energy.
42.	WATER	Is the chief component of our body.
43.	FATS	Make up about 15% of our body weight.
44.	VITAMIN D	Is important for healthy bones.
45.	CARBOHYDRATES	Help regulate protein and fat use in our body.
46.	PROTEINS	Are the chief ingredient of hair, nail, muscle, and skin.
47.	CALCIUM	Is the chief mineral in our body.
48.	WATER	Helps cool the body.

STUDENT ROLE

Nutritionist

MATERIALS

48 NUTRIENT CARDS from Master Set A
48 FUNCTION CARDS from Master Set B
48 FOOD GROUP CARDS from Master Set C
scissors
Student Pages 5.5.1A THE FOOD GUIDE PYRAMID
5.5.1B NUTRIENT CARD GAMES
5.5.1C NUTRIENTS AND THEIR FUNCTIONS

PRODUCTS

Nutrient Game sets
Completed Student Pages

PROCEDURES

1. **Have the students develop a concept map of the term nutrients.**

   Help them include such things as these:
   - Body-building chemicals.
   - Body-regulating chemicals.
   - Body-activating or energizing chemicals.
   - Carbohydrates.

- Fats.
- Proteins.
- Minerals.
- Vitamins.
- Water.

2. **Have the students assemble the cards for the NUTRIENT-FUNCTION GAME.**

   Have them
   - Cut out a set of NUTRIENT cards and tape them shut. These cards have the *nutrient* on one side and the *function of that nutrient* on the other.
   - Cut out a set of FUNCTION cards. These cards have *one function* listed on one side and a *blank* on the other side.

3. **Introduce the game rules. Have the students use Student Page 5.5.1A THE FOOD GUIDE PYRAMID and play the NUTRIENT-FUNCTION GAME.**

4. **Summarize the NUTRIENT-FUNCTION GAME using Student Page 5.5.1C NUTRIENTS AND THEIR FUNCTIONS. Have the students work in their game groups. Have them fill in the blanks from memory and *then* use their NUTRIENT cards to verify their answers.**

5. **Have the students make the NUTRIENT-FOOD GROUP GAME cards.**

   Have them
   - Cut out a set of FOOD GROUP cards and tape them shut. These cards have the *food group* on one side and the *nutrients of that group* on the other.
   - Collect the NUTRIENT CARDS used in the NUTRIENT-FUNCTION GAME.
   - Refer to Student Page 5.5.1A FOOD GUIDE PYRAMID to refresh their memory of the foods in the groups.

6. **Introduce the rules for the NUTRIENT-FOOD GROUP GAME. See Student Page 5.5.1C. Have the students play the game.**

7. Summarize the NUTRIENT-FOOD GROUP GAME.

Ask such questions as these:

- Are all foods rich in the same nutrients? (Work to the idea that because foods are rich in only certain nutrients, we must group them.)
- Why would a can of sardines be rich in calcium, while a boneless fillet of catfish would not? (Work to the observation that usually we eat the entire sardine including the bones and only the flesh of the catfish. Bones are very rich in calcium.)
- Why is milk rich in so many nutrients? (It is the first food of most infants and other mammals and contains a well-rounded supply of nutrients to ensure the growth and survival of the newborn.)
- What are the minerals shown on the NUTRIENT CARDS? (Work for agreement that they are iron, phosphorus, and calcium.)
- Are there other minerals that are important to us? (Have the students put this into the Wonder and Discover Book. Suggest that they can look at the vitamin-and-mineral display at their drug store as a starting point.)
- Are there other vitamins that are important to us? (Again suggest that they can look at the vitamin-and-mineral display at their drug store as a starting point.)

EXTENSIONS

- Put the game in the science center and encourage students to play it.
- Have students invent their own variations of the game and report on these to the class.
- Have students make a nutrient display, adding other minerals and vitamins and their functions as they find them.

GAME CARDS

MASTER SET (A) NUTRIENT CARDS 12 cards (4 copies each page) page 1

FUNCTIONS • Is the chief mineral in our body. • Makes up about 3% of our • Is the chief mineral in bones and teeth. • Helps in blood clotting. • Helps regulate heartbeat.	**NUTRIENT** CALCIUM	**FUNCTIONS** • Is the second most abundant mineral in our body. • Makes up about 1% of our body weight. • Helps start muscle contractions. • Helps digest vitamins. • Helps in energy storage.	**NUTRIENT** PHOSPHORUS
FUNCTIONS • Helps carry oxygen in our body. • Gives blood its red color. • Is stored in the liver. • Helps in use of proteins.	**NUTRIENT** IRON	**FUNCTIONS** • Helps repair our body tissue. • Helps protect mouth, nose, throat, and lung tissue from infection. • Is an essential chemical in night vision. • Needed for reproduction. • Helps in growth of our body tissue.	**NUTRIENT** VITAMIN A

BEST COPY AVAILABLE

MASTER SET (A) NUTRIENT CARDS 12 cards (4 copies each page) page 2

FUNCTIONS • Helps in digestion of carbohydrates. • Helps maintain our muscles. • Helps maintain healthy skin, hair, and eyes.	**NUTRIENT** VITAMIN B COMPLEX	**FUNCTIONS** • Helps heal burns and other wounds. • Helps maintain connective tissue—fat, cartilage, tendons, and bones. • Helps prevent viral and bacterial infection. • Helps prevent breakdown of other vitamins. • Helps maintain our muscles.	**NUTRIENT** VITAMIN C
FUNCTIONS • Helps in use of calcium. • Is important for healthy bones. • Is a product of body's exposure to sunlight. • Helps in use of phosphorus.	**NUTRIENT** VITAMIN D	**FUNCTIONS** • Are the chief source of our body's energy. • Make up about 2% of our body's weight. • Provide roughage (indigestible fiber) to aid digestion. • Help regulate protein and fat use in our body. • Are changed to fat for storage.	**NUTRIENT** CARBOHYDRATES

BEST COPY AVAILABLE

MASTER SET (A) NUTRIENT CARDS 12 cards (4 copies each page) page 3

FUNCTIONS

- Are the most concentrated source of energy in our body.
- Make up about 15% of our body weight.
- Cover and protect vital organs.
- Insulate our body from heat loss.
- Dissolve and carry Vitamins A, D, E, and K.

NUTRIENT

FATS

FUNCTIONS

- Are the chief body-building material.
- Make up about 14% of our body's weight.
- Are the chief ingredient of hair, nails, muscle, and skin.
- Build enzymes that regulate our body.
- Are a reserve source of energy.

NUTRIENT

PROTEINS

FUNCTIONS

- Is the chief component of our body.
- Makes up about 65% of our body weight.
- Helps dissolve all materials carried by the blood.
- Carries waste from the body in urine and sweat.
- Helps cool the body.

NUTRIENT

WATER

FUNCTIONS

- Is the chief component of our body.
- Makes up about 65% of our body weight.
- Helps dissolve all materials carried by the blood.
- Carries waste from the body in urine and sweat.
- Helps cool the body.

NUTRIENT

WATER

BEST COPY AVAILABLE

MASTER SET (B) FUNCTION CARDS 48 cards (1 copy each page) page 1

FUNCTION • Is the chief mineral in our body.	**FUNCTION** • Makes up about 3% of our body weight.	**FUNCTION** • Is the chief mineral in bones and teeth.	**FUNCTION** • Helps in blood clotting.
FUNCTION • Is the second most abundant mineral.	**FUNCTION** • Makes up about 1% of our body weight.	**FUNCTION** • Helps start muscle contractions.	**FUNCTION** • Helps in energy storage.

MASTER SET (B) FUNCTION CARDS 48 cards (1 copy each page) page 2

FUNCTION • Helps carry oxygen in our body.	**FUNCTION** • Gives blood its red color.	**FUNCTION** • Is stored in the liver.	**FUNCTION** • Helps in use of proteins.
FUNCTION • Helps in growth of our body tissue.	**FUNCTION** • Helps repair our body tissue.	**FUNCTION** • Helps protect mouth, nose, throat, and lung tissues from infection.	**FUNCTION** • Is an essential chemical in night vision.

MASTER SET (B) FUNCTION CARDS 48 cards (1 copy each page) page 3

FUNCTION • Helps in digestion of carbohydrates.	**FUNCTION** • Helps maintain our nervous system.	**FUNCTION** • Helps maintain our muscles.	**FUNCTION** • Helps maintain healthy skin, hair, and eyes.
FUNCTION • Helps heal burns and other wounds.	**FUNCTION** • Helps maintain connective tissue, fat, cartilage, tendons, and bones.	**FUNCTION** • Helps prevent viral and bacterial infection.	**FUNCTION** • Helps prevent breakdown of other vitamins.

MASTER SET (B) FUNCTION CARDS 48 cards (1 copy each page) page 4

FUNCTION

- Helps in the use of calcium.

FUNCTION

- Is important for healthy bones.

FUNCTION

- Is a product of the body's exposure to sunlight.

FUNCTION

- Helps in the use of phosphorus.

FUNCTION

- Are the chief source of our body's energy.

FUNCTION

- Make up about 2% of our body's weight.

FUNCTION

- Provide roughage (indigestible fiber) to aid digestion.

FUNCTION

- Are changed to fat for storage.

MASTER SET (B) FUNCTION CARDS 48 cards (1 copy each page) page 5

FUNCTION • Are the most concentrated source of energy in our body.	**FUNCTION** • Make up about 15% of our body weight.	**FUNCTION** • Insulate our body from heat loss.	**FUNCTION** • Dissolve and carry vitamins A, D, E, and K.
FUNCTION • Are the chief body-building material.	**FUNCTION** • Make up about about14% of our body weight.	**FUNCTION** • Is the chief ingredient of hair, nails, muscle, and skin.	**FUNCTION** • Build enzymes that regulate our body.

MASTER SET (B) FUNCTION CARDS 48 cards (1 copy each page)   page 6

FUNCTION

- Is the chief component of our body.

FUNCTION

- Make up about 65% of our body weight.

FUNCTION

- Helps dissolve all materials carried by the blood.

FUNCTION

- Carries waste from the body in urine and sweat.

FUNCTION

- Cover and protect vital organs.

FUNCTION

- Are a reserve source of energy.

FUNCTION

- Help regulate protein and fat use in our body.

FUNCTION

- Helps cool our body.

MASTER SET (C) FOOD GROUP CARDS 16 cards (3 copies each page) page 1

PRINCIPAL NUTRIENTS • Carbohydrates • Vitamin B Complex • Proteins • Calcium	**FOOD GROUP** BREAD, CEREAL, RICE, AND PASTA 6–11 Servings	PRINCIPAL NUTRIENTS • Vitamin C • Carbohydrates • Water • Vitamin A	**FOOD GROUP** FRUIT 2–4 Servings
PRINCIPAL NUTRIENTS • Iron • Vitamin A • Carbohydrates • Water	**FOOD GROUP** VEGETABLE 3–5 Servings	PRINCIPAL NUTRIENTS • Calcium • Phosphorus • Vitamin D • Proteins • Vitamin B Complex • Carbohydrates • Water	**FOOD GROUP** MILK, YOGURT, AND CHEESE 2–3 Servings

MASTER SET (C) FOOD GROUP CARDS 16 cards (3 copies each page) page 2

PRINCIPAL NUTRIENTS • Proteins • Vitamin B Complex • Fats	**FOOD GROUP** MEAT, POULTRY, FISH, DRY BEANS, EGGS, AND NUTS 2–3 Servings	PRINCIPAL NUTRIENTS • Fats • Carbohydrates	**FOOD GROUP** FATS, OILS, AND SWEETS Sparingly
PRINCIPAL NUTRIENTS • Carbohydrates • Vitamin B Complex • Proteins • Calcium • Iron	**FOOD GROUP** BREAD, CEREAL, RICE, AND PASTA 6–11 Servings	PRINCIPAL NUTRIENTS • Carbohydrates • Vitamin B Complex • Proteins • Calcium • Iron	**FOOD GROUP** BREAD, CEREAL, RICE, AND PASTA 6–11 Servings

MASTER SET (C) FOOD GROUP CARDS 16 cards (3 copies each page) page 3

PRINCIPAL NUTRIENTS • Proteins • Vitamin B Complex • Fats	**FOOD GROUP** MEAT, POULTRY, FISH, DRY BEANS, EGGS, AND NUTS 2–3 Servings	**PRINCIPAL NUTRIENTS** • Proteins • Vitamin B Complex • Fats	**FOOD GROUP** MEAT, POULTRY, FISH, DRY BEANS, EGGS, AND NUTS 2–3 Servings
PRINCIPAL NUTRIENTS • Vitamin C • Carbohydrates • Water • Vitamin A	**FOOD GROUP** FRUIT 2–4 Servings	**PRINCIPAL NUTRIENTS** • Iron • Vitamin A • Carbohydrates • Water	**FOOD GROUP** VEGETABLE 3–5 Servings

MASTER SET (C) FOOD GROUP CARDS 16 cards (3 copies each page) page 4

PRINCIPAL NUTRIENTS

- Carbohydrates
- Vitamin B Complex
- Proteins
- Calcium
- Iron

FOOD GROUP

BREAD, CEREAL, RICE,
AND
PASTA

6–11 Servings

PRINCIPAL NUTRIENTS

- Vitamin C
- Carbohydrates
- Water
- Vitamin A

FOOD GROUP

FRUIT

2–4 Servings

PRINCIPAL NUTRIENTS

- Iron
- Vitamin A
- Carbohydrates
- Water

FOOD GROUP

VEGETABLE

3–5 Servings

PRINCIPAL NUTRIENTS

- Calcium
- Phosphorus
- Vitamin D
- Proteins
- Vitamin B Complex
- Carbohydrates
- Water

FOOD GROUP

MILK, YOGURT,
AND
CHEESE

2–3 Servings

DASH

SP 5.5.1A
THE FOOD GUIDE PYRAMID

Name ______________________________

Date ______________________________

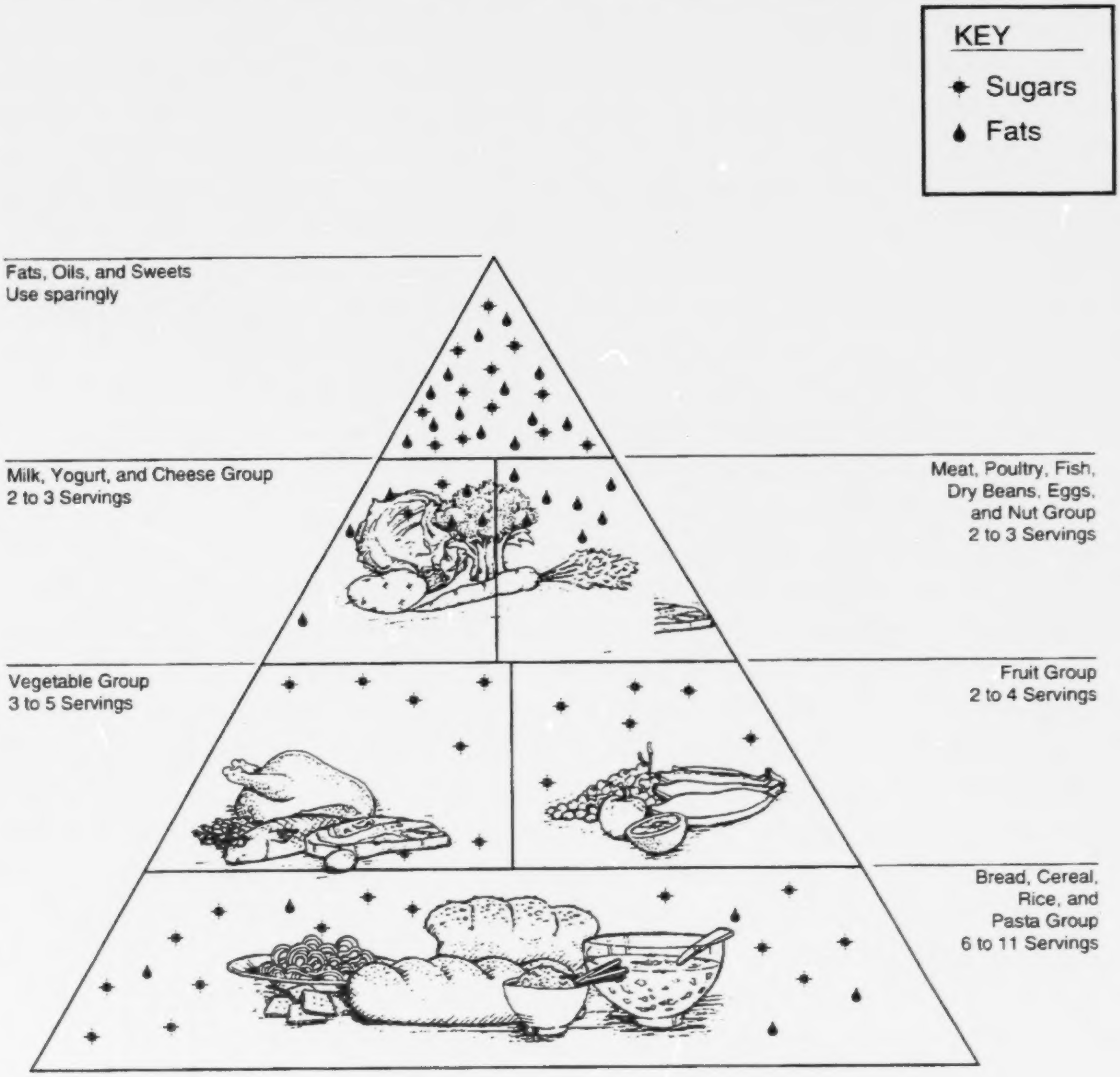

KEY
✦ Sugars
● Fats
Fats, Oils, and Sweets
Use sparingly
Milk, Yogurt, and Cheese Group
2 to 3 Servings
Meat, Poultry, Fish, Dry Beans, Eggs, and Nut Group
2 to 3 Servings
Vegetable Group
3 to 5 Servings
Fruit Group
2 to 4 Servings
Bread, Cereal, Rice, and Pasta Group
6 to 11 Servings

Figure SP 5.5.1A The Food Guide Pyramid

DASH

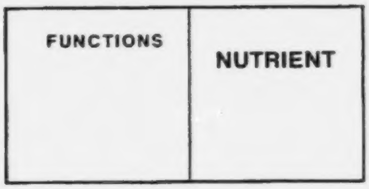
Name________________________

Date________________________

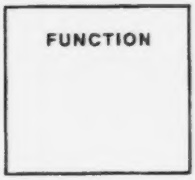
STUDENT PAGE 5.5.1B NUTRIENT CARD GAMES

1. Assemble the cards for THE NUTRIENT CARD GAMES. There are three decks of cards with 48 cards in each deck

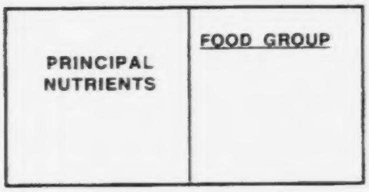
- NUTRIENT CARDS have a *nutrient* name on the face and a listing of the major *functions* of that nutrient on the back. Cut along the heavy lines. Fold along the dotted lines and tape the cards shut.



- FUNCTION CARDS have a single nutrient *function* on their face and a blank on their back. Cut along the heavy lines.



- FOOD GROUP CARDS have a *food group* on their face and the *principal nutrients* found in foods in the Food Group listed on their back. Cut along the heavy lines. Fold along the dotted lines and tape the cards shut.



Name________________________________

2. **Play the NUTRIENT-FUNCTION GAME using the following rules.**

NUTRIENT-FUNCTION GAME

Number of players

2 to 4

Objective

To match **NUTRIENT CARDS** and **FUNCTION CARDS**.

Winner

The student who matches the most **FUNCTION** and **NUTRIENT CARDS**.

Play

- Separate the **NUTRIENT CARDS** from the **FUNCTION CARDS**, making two decks. Shuffle each deck separately.
- Place the **NUTRIENT CARD DECK** with the ***nutrient face up.***
- Deal 3 **FUNCTION CARDS** to each player with the ***blank side face up.***
- Place the remaining deck of **FUNCTION CARDS** next to the **NUTRIENT CARDS** with the ***blank side up.***
- Player 1 tries to match one Function card in the hand with the nutrient shown on the **NUTRIENT CARD** exposed on the deck.
- If successful in making a match, the player puts a **FUNCTION-AND-NUTRIENT CARD PAIR** in a personal pile. So all can see whether the match is correct or incorrect, the functions of the nutrient listed on the back of the **NUTRIENT CARD** are read aloud.
- If successful in making a match, the player replaces the first **FUNCTION CARD** in the hand with the card on the top of the **FUNCTION DECK.**
- If no match is made, the **NUTRIENT CARD** shown on the top of the **NUTRIENT DECK** is put on the bottom of the deck thus exposing a new **NUTRIENT CARD** for Player 2.
- Each successive player follows the same procedure as Player 1 until there are no more **FUNCTION CARDS** or no play is possible.

Name_______________________________

3. **Play the NUTRIENT-FOOD GROUP GAME using the following rules.**

NUTRIENT-FOOD GROUP GAME

Number of players

2 to 4

Objective

To match **NUTRIENT CARDS** with the proper **FOOD GROUP CARDS.**

Winner

The student who is able to match the most cards.

Play

- Separate the **NUTRIENT CARDS** from the **FOOD GROUP CARDS**, making two decks. Shuffle each deck separately.
- Place the **FOOD GROUP DECK** so the **FOOD GROUP** is ***face up.***
- Deal 3 **NUTRIENT CARDS** to each player with the ***nutrient face down.***
- Place the remaining **NUTRIENT CARDS** next to the **FOOD GROUP CARDS** with the ***nutrient face down.***
- Player 1 tries to match a **NUTRIENT CARD** in the hand with the Food Group shown on the **FOOD GROUP DECK**.
- If successful in making a match, the player puts a **NUTRIENT CARD-AND-FOOD GROUP CARD PAIR** in a personal pile. So all can see whether the match is correct, the nutrients found in abundance in the food group are listed on the back of the **FOOD GROUP CARDS** and are read aloud.
- If successful in making a match, the player replaces the **NUTRIENT CARD** in the hand with another taken from the top of the **NUTRIENT DECK**.
- If no match is made, the **FOOD GROUP CARD** is put on the bottom of the deck and a new **FOOD GROUP CARD** is exposed for Player 2.
- Each successive player follows the same procedure as Player 1 until there are no more **FOOD GROUP CARDS** or no play is possible.

DASH

Name____________________________

Date_____________________________

STUDENT PAGE 5.5.1C NUTRIENTS AND THEIR FUNCTIONS

Write in the name of the *nutrients* that match the *functions* listed.

1.		Helps carry oxygen in our body.
2.		Carries waste from the body in urine and sweat.
3.		Helps in blood clotting.
4.		Helps heal burns and other wounds.
5.		Is the second most abundant mineral in our body.
6.		Gives blood its red color.
7.		Dissolve and carry Vitamins A, D, E, and K.
8.		Helps start muscle contractions.
9.		Helps maintain our nervous system.
10		Helps dissolve all materials carried by the blood.
11.		Is the chief mineral in bones and teeth.
12.		Helps in growth of our body tissue.
13.		Is stored in the liver.
14.		Is an essential chemical in night vision.
15.		Helps in digestion of carbohydrates.

Name________________________________

16.		Is a product of the body's exposure to sunlight.
17.		Helps protect mouth, nose, throat, and lung tissue from infection.
18.		Helps maintain healthy skin, hair, and eyes.
19.		Makes up about 3% of our body weight.
20.		Helps maintain connective tissue—fat, cartilage, tendons, and bones.
21.		Makes up about 1% of our body weight.
22.		Helps in the use of proteins.
23.		Helps maintain our muscles
24.		Helps prevent breakdown of other vitamins.
25.		Are changed to fat for storage.
26.		Helps in use of calcium.
27.		Helps repair our body tissue.
28.		Helps prevent viral and bacterial infection.
29.		Are the chief source of our body's energy.
30.		Helps in energy storage.
31.		Build enzymes that regulate our body.
32.		Helps in use of phosphorus.
33.		Provide roughage (indigestible fiber) to aid digestion.
34.		Are the most concentrated source of energy in our body.
35.		Insulate our body from heat loss.

Name________________________________

36.		Make up about 2% of our body weight.
37.		Are the chief body-building material.
38.		Makes up about 65% of our body weight.
39.		Makes up about 14% of our body weight.
40.		Cover and protect vital organs.
41.		Are a reserve source of energy.
42.		Is the chief component of our body.
43.		Make up about 15% of our body weight.
44.		Is important for healthy bones.
45.		Help regulate protein and fat use in our body.
46.		Are the chief ingredient of hair, nail, muscle, and skin.
47.		Is the chief mineral in our body.
48.		Helps cool the body.

ACTIVITY 5.5.2 NUTRIENTS AND CELLS

OBJECTIVES

The students
- Simulate the digestion of raw food.
- Follow the nutrients as they are processed and used in the body.

BACKGROUND

This is the second activity in the nutrition series. It should follow Activity 5.5.1 NUTRIENTS. In NUTRIENTS AND CELLS the students review six kinds of nutrients and the cellular nature of raw foods taken from plants and animals. They then build models of cells and use a schematic to simulate the digestion and use of nutrients. As a summary the students are asked to record what happens to nutrients in various body organs.

Preparation

Divide the class into eight groups representing the eight systems represented in the simulation.

- Mouth
- Stomach
- Small intestine
- Large intestine
- Liver
- Heart-and-lung
- Kidney
- Body tissue

Three to four students will be needed for each group. Have the groups assemble simulated cells and give them a copy of the schematic found in Figure SP 5.5.2(7) and the Fact Sheet on organs and digestion. Assign each group an organ or the body tissues and have them create a scenario for a playlet demonstrating how these body parts operate on nutrient materials. Each group should look up any terms they do not know and add their definitions to the Working Dictionary.

Making a Simulated Cell

Each group should make two or more cells out of the nutrients found in raw foods. See Figures SP 5.5.2(1–6). Have them cut out and fold the nutrient strips into triangles. They can use paper clips or tape to fasten the triangles together. The cells will be hexagons with one of the six nutrients on each of their six faces. Have the students assemble additional triangles of water, oxygen, and complex carbohydrate roughage.

The Body

Have a large copy of the food schematic drawn on the floor or on butcher paper. See Figure SP 5.5.2.(7). Groups should place the nutrient pieces in their systems as they demonstrate what happens to the nutrients or products.

The Simulation

Have the groups describe and act out the functions of the organ they represent. The paper representations of nutrient cells can be used to show what happens as nutrients are released in digestion, pass into the body, and become waste products or are reconstructed as new cells.

Digestive Tract groups can disassemble the appropriate parts of their cell as the nutrient passes through them. Digestion can be shown by folding and turning up the digestion side of the appropriate nutrient triangle. See Figures 5.5.2(1–3). Remaining organ groups show the processes they perform.

STUDENT ROLE

Physiologist

MATERIALS

scissors
paper clips
tape
Student Page 5.5.2 NUTRIENTS IN CELLS.

PRODUCTS

Playlets about nutrients
Simulated nutrient cells
Completed Student Page

PROCEDURES

1. **Have the students develop working definitions of the terms nutrients, cells, tissues, and organs.**

Help them include such things as

- *Nutrients* are the chemicals that make up foods.
- *Nutrients* are classified as *water, proteins, carbohydrates, fats, vitamins,* and *minerals*.
- *Cells* are the smallest units of life. (Examples of cells include single-celled organisms such as bacteria and amoebae and the units making up the tissues of multi-celled organisms.)
- *Tissues* are groups of cells in a multi-celled organism that do the same things.
- *Organs* are groups of two or more tissues organized to perform a special function. (Examples of organs include hearts, lungs, stomachs, roots, stigma, and so forth.)
- *Raw foods* are the plant and animal tissues eaten by animals. (Examples of raw foods include nuts, fruits, steaks, liver, eggs, and so forth.)

2. **Have the students divide into eight groups—one group for each of the systems shown in Figure SP 5.5.2(7)—and prepare for the simulation.**

Help them

- Cut out and assemble 2 cells per group.
- Cut out and assemble extra complex carbohydrate roughage, water, and oxygen strips.
- Insert a triangle of complex carbohydrate roughage in each cell.
- Get their organ assignment.
- Read about the functions of each organ system and develop a scenario to tell the story of their organ's contribution to "a day in the lives of some nutrients."
- Make a large-scale drawing of the organs and the connecting vascular system. See Figure SP 5.5.2(7). (The drawing can be made on the floor in chalk or on butcher paper so that the simulated cells can be moved through the systems.)

3. **Have the students carry out the simulation.**

Have them

- Start with the *Mouth* and follow the numbers.
- Interpret what happens to the cellular food, nutrients, or waste products being carried to the organs.

- Disassemble and reassemble the cell as required.
- As the nutrients are digested, turn over the cards and note the form the nutrients take in the blood, tissue, and organs of waste removal.

4. **Have the students use Student Page 5.5.2 NUTRIENTS IN CELLS to record what happens to food, nutrients, oxygen, and wastes as they are processed in the body.**

5. **Help the students reflect on the simulation.**

Ask such questions as these:
- What are biological needs of living things? (Help them recall the needs for food, water, and oxygen for animals and nutrients and carbon dioxide for plants. Other needs are for appropriate temperature control, reproduction, and waste removal.)
- What are the biological needs of the cells in our body? (Get at the idea that they are the same as those of animals.)
- What do you think the biological needs of micro-organisms might be? (Work to the idea that if they are animal-like, they would be the same as those of other animals. If they are plant-like, they would be the same as those of plants.)
- How do the nutrient triangles represent the chemicals that make up cells? (Work to the idea that the chemicals found in cells are classified as *nutrients*, and there are *six kinds* of nutrients.)

EXTENSIONS

Have the students
- Write a history of the digestion, absorption, and use of the nutrients in a potato.
- Construct a mural showing the functions of the organs of the game.

DASH

Name________________________

Date________________________

STUDENT PAGE 5.5.2 NUTRIENTS IN CELLS

1. With your group cut out the strips representing nutrients in cells. See Figures SP 5.5.2(1–3). Assemble the strips into hexagon "cells" using Figures SP 5.5.2(4–6). Insert a triangle of complex carbohydrate roughage in each cell.

2. Describe what happens to the six nutrients as they are processed in the body.

CARBOHYDRATES

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FATS

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Name________________________

PROTEINS

MINERALS

VITAMINS

SP 5.5.2–3

Name______________________________

WATER

Name________________________

FACT SHEET: ORGANS AND DIGESTION

* * * * * * * * * * *

THE MOUTH AND DIGESTION

- The mouth is a place of mechanical food breakdown and chemical digestion.
- Chewing crushes and tears apart food tissue.
- Chewing moistens food with saliva.
- Saliva makes the passage of food into the stomach easier.
- Saliva contains *ptyalin,* which works at digesting complex carbohydrates, particularly starch from grains.
- Crushed, moistened food is sent to the stomach by swallowing.

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THE STOMACH AND DIGESTION

- The stomach is about the size of two fists and is an elastic bag with many irregular ridges on its inside.
- The stomach is constantly contracting and expanding to mix food with gastric or digestive juices.
- One of the gastric juices in the stomach is hydrochloric acid, which produces a pH of about 1. (This is a very high acid concentration.)
- This hydrochloric acid is produced in the walls of the stomach.
- The hydrochloric acid kills most bacteria in food.
- Gastric juices begin digestion of protein.
- Gastric juices also clot milk.
- After 3–4 hours of constant churning, the contents of the stomach are a watery mixture like split pea soup called *chyme.*
- The chyme is sent on to the small intestine.

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Name________________________________

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THE SMALL INTESTINE AND DIGESTION

- The small intestine is connected to the stomach by a muscular valve called the *pyloric valve.*
- The small intestine is about 4 times as long as the person is tall and 2.5 to 4 cm in diameter.
- Bile from the liver enters the small intestine close to the pyloric valve.
- Bile helps break up fats and put them into solution.
- Digestive juices from the pancreas enter the small intestine at about the same place that the bile enters.
- Pancreatic juices help digest fats, proteins, and carbohydrates.
- Digestive juices from the intestinal wall help digest proteins and carbohydrates.
- Digestive juices release minerals and vitamins so they can be absorbed in the bloodstream.
- The small intestine is where nutrients are absorbed into the bloodstream.
- Between 95% and 99% of the proteins in food are broken down to amino acids and absorbed into the bloodstream.
- About 95% of the fat in food is directly absorbed into the bloodstream.
- About 80% of the carbohydrates in food are absorbed into the bloodstream as sugars.
- Between 80–90% of the vitamins and minerals are absorbed into the bloodstream.
- About 60% of the water from food, drink, and digestive juices is absorbed into the bloodstream.

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Name______________________________

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THE LARGE INTESTINE AND DIGESTION

- The large intestine connects to the small intestine.
- The large intestine is 1–2 meters long and 5–8 cm in diameter.
- The large intestine is the place for storage of undigested food.
- Most of the remaining 40% of the water from food, drink, and digestive juices is absorbed into the bloodstream from the large intestine.
- Undigested materials, particularly complex carbohydrates, roughage, and bacteria are compacted into a stool that leaves the body in the process called *defecation*. Bacteria produce the gas that accompanies the stool.
- In times of illness the water-removal function of the large intestine may be reversed, and the stool may be liquefied for rapid removal.

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THE LIVER AND ABSORBED NUTRIENTS

- Blood, carrying nutrients from the intestines, goes directly to the liver.
- The liver converts poisonous materials from the blood into non-poisonous materials in a process called *detoxification*.
- Much of the detoxified material goes into bile, which the liver pours into the small intestine.
- Alcohol is detoxified in the liver and converted to water and carbon dioxide.
- Sugar from carbohydrates is stored in the liver for a short time to supply energy between meals.
- Excess amino acid from protein is broken down into urea, which is extracted by the kidney.

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Name________________________________

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THE HEART AND LUNGS

- Blood from the liver and the rest of the body is pumped by the heart to the lungs.
- In the lungs carbon dioxide and some water leave the blood and pass into the air.
- Carbon dioxide and water come from carbohydrates, fats, proteins, and other chemicals in the blood as they oxidize or burn to produce our body's energy.
- In the lungs oxygen from the air is taken into the blood.
- Oxygen-rich and nutrient-rich blood is pumped by the heart from the lungs on three major pathways:
    - Blood may go to the body tissues to carry out body processes.
    - Blood may go to the kidneys for further cleaning.
    - Blood may go back to the digestive tract to pick up more nutrients.

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THE KIDNEYS

- In the kidneys wastes are removed from the blood.
- Wastes include urea, excess dissolved minerals, and excess vitamins.
- Wastes are mixed with water and become urine.
- Urine is stored in the bladder until urination.
- We normally begin to feel the need to urinate when the bladder is about half full.
- We release between 1.5 to 2 liters of urine a day, depending on the temperature and the amount we drink.
- We normally get more of our water from foods and oxidation of nutrients than from drinks.
- Cleansed blood from the kidneys returns to the heart.

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Name______________________________

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THE BODY TISSUES

In the tissues of the body the nutrients and oxygen contents of the blood are used to carry out three basic functions:

- **Nutrients fabricate or build cells.**
  - *Fabrication* requires a proper mix of all six basic nutrients found in food.
  - In *fabrication* the six nutrients are reassembled into new cells.
  - *Fabrication* replaces injured or worn-out cells.
  - *Fabrication* permits the body to grow by building new cells.
- **Nutrients regulate or direct the operations or workings of cells.**
  - *Regulation* requires vitamins, minerals, and chemicals made by cells.
- **Nutrients activate the cells or produce the energy necessary to run them.**
  - *Activation* involves oxidizing or burning of carbohydrates, fats, and proteins to produce energy.
  - Burning nutrients requires oxygen, which is carried by the blood.
  - Burning forms carbon dioxide and water, which are released from the blood by the lungs. Water is also released by the kidneys and passes into the large intestine.
  - Cells usually burn carbohydrates.
  - Fats and proteins are burned mostly when nutrient carbohydrates are used up.
  - Excess carbohydrates are converted to fats, which are stored in fat cells.
  - Cells also produce waste products as they operate and wear out.
  - Cell wastes are released into the blood.
  - These wastes are made (detoxified) in the liver and removed from it as *bile* or from the kidneys as *urine*.

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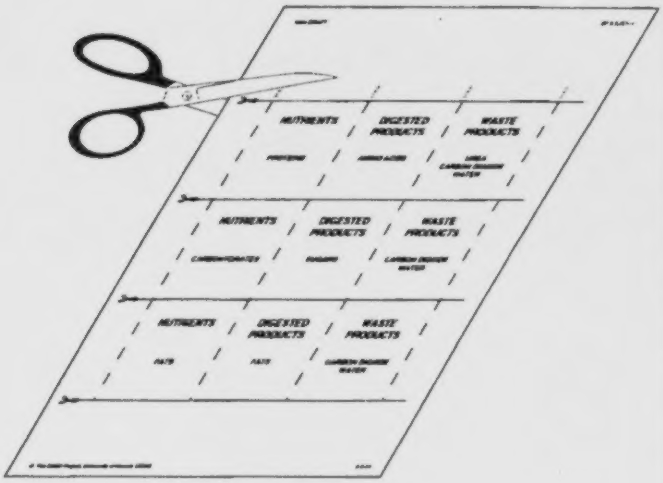
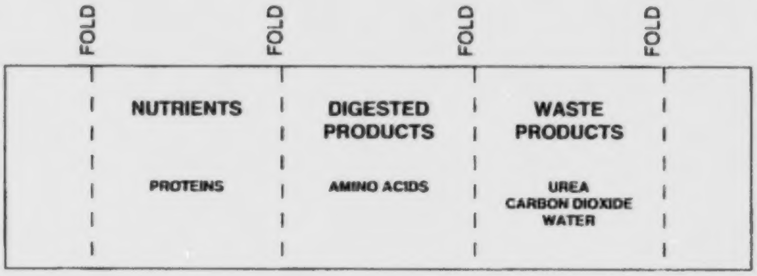
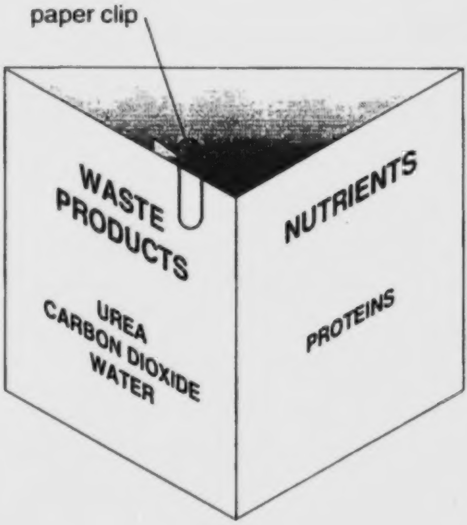
ILLUSTRATIONS


NUTRIENTS
DIGESTED PRODUCTS
WASTE PRODUCTS
PROTEINS
AMINO ACIDS
UREA CARBON DIOXIDE WATER
NUTRIENTS
DIGESTED PRODUCTS
WASTE PRODUCTS
CARBOHYDRATES
SUGARS
CARBON DIOXIDE WATER
NUTRIENTS
DIGESTED PRODUCTS
WASTE PRODUCTS
FATS
FATS
CARBON DIOXIDE WATER

① Cut along path indicated by scissors. ✂


FOLD
FOLD
FOLD
FOLD
NUTRIENTS
DIGESTED PRODUCTS
WASTE PRODUCTS
PROTEINS
AMINO ACIDS
UREA
CARBON DIOXIDE
WATER

② Fold on the dotted lines.


paper clip
WASTE PRODUCTS
UREA
CARBON DIOXIDE
WATER
NUTRIENTS
PROTEINS

③ Form a triangle and hold with a paper clip.
Place clip on the side marked **WASTE PRODUCTS.**

Figure SP 5.5.2 (1) Assembling pieces for a nutrient cell

BEST COPY AVAILABLE

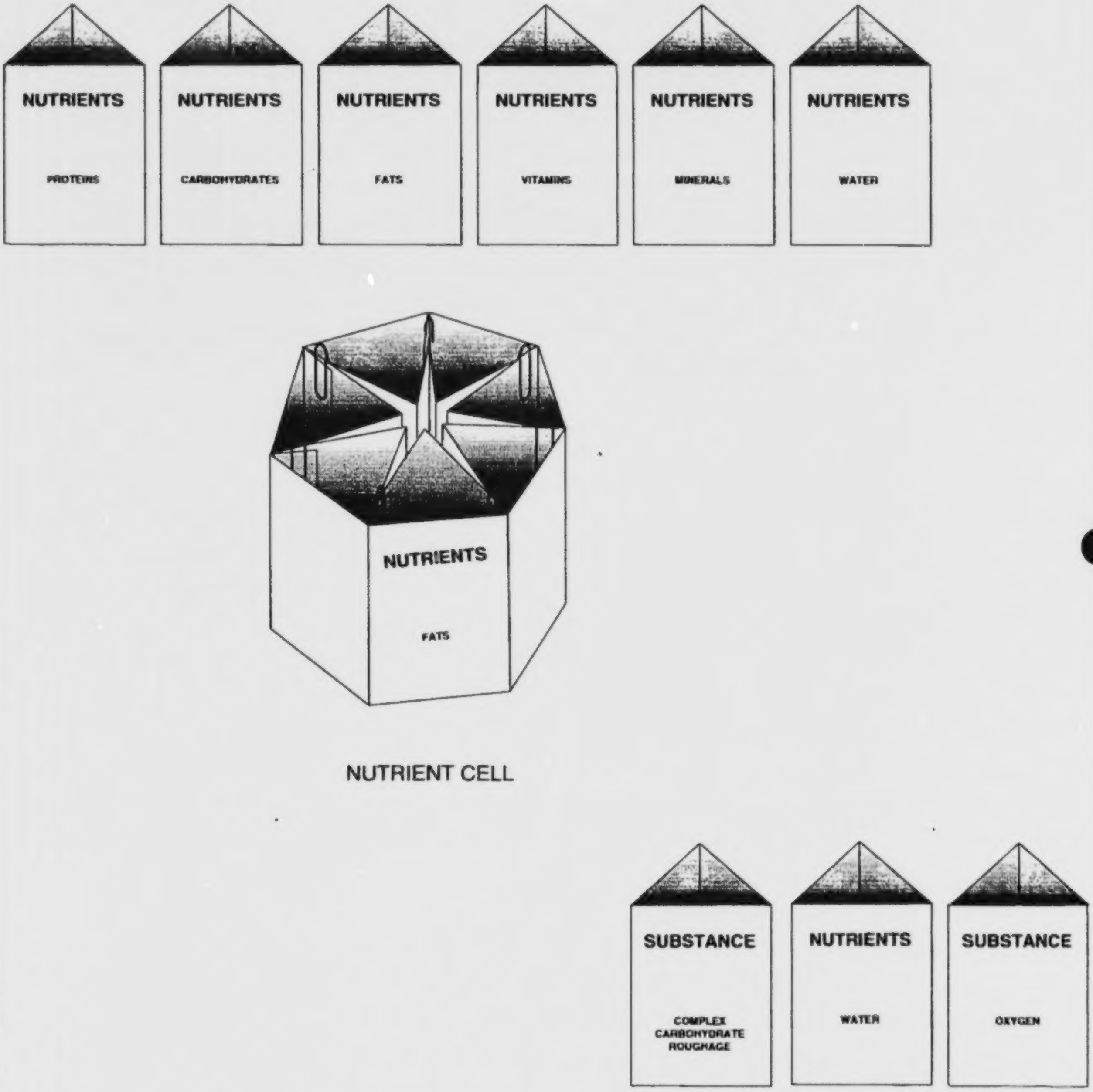

NUTRIENTS
PROTEINS
NUTRIENTS
CARBOHYDRATES
NUTRIENTS
FATS
NUTRIENTS
VITAMINS
NUTRIENTS
MINERALS
NUTRIENTS
WATER
NUTRIENTS
FATS
NUTRIENT CELL
SUBSTANCE
COMPLEX CARBOHYDRATE ROUGHAGE
NUTRIENTS
WATER
SUBSTANCE
OXYGEN

Figure SP 5.5.2(2) Assembling a nutrient cell

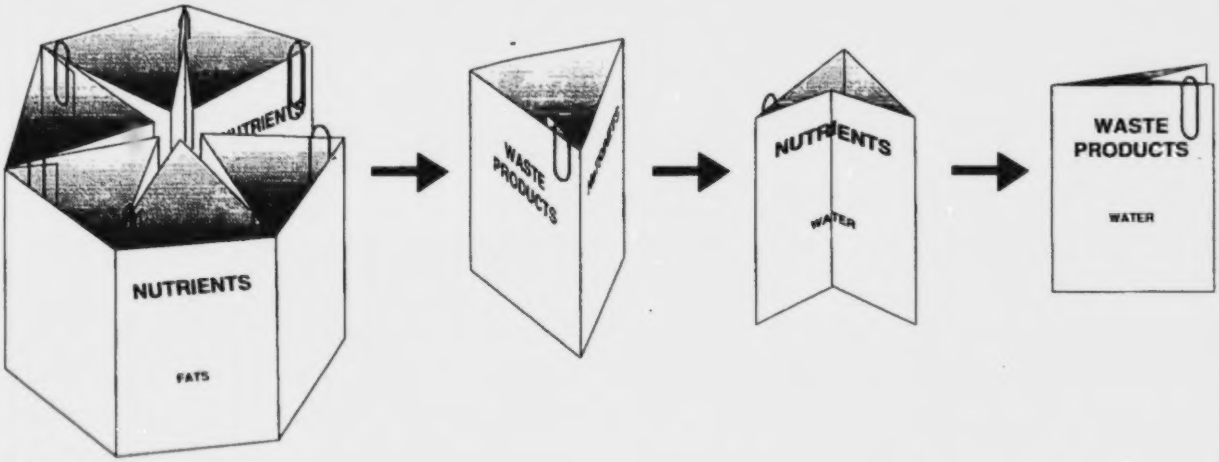

NUTRIENTS
NUTRIENTS
FATS
WASTE PRODUCTS
NUTRIENTS
WATER
WASTE PRODUCTS
WATER

Figure SP 5.5.2(3) Disassembling a nutrient cell

FOLD FOLD FOLD FOLD

NUTRIENTS PROTEINS	**DIGESTED PRODUCTS** AMINO ACIDS	**WASTE PRODUCTS** UREA CARBON DIOXIDE WATER
NUTRIENTS CARBOHYDRATES	**DIGESTED PRODUCTS** SUGARS	**WASTE PRODUCTS** CARBON DIOXIDE WATER
NUTRIENTS FATS	**DIGESTED PRODUCTS** FATS	**WASTE PRODUCTS** CARBON DIOXIDE WATER

Figure SP 5.5.2(4) Nutrient strips

FOLD FOLD FOLD FOLD

NUTRIENTS VITAMINS	**DIGESTED PRODUCTS** VITAMINS	**WASTE PRODUCTS** VITAMINS CARBON DIOXIDE WATER
NUTRIENTS MINERALS	**DIGESTED PRODUCTS** MINERALS	**WASTE PRODUCTS** MINERALS
NUTRIENTS WATER	**DIGESTED PRODUCTS** WATER	**WASTE PRODUCTS** WATER

Figure SP 5.5.2(5) Nutrient strips

FOLD FOLD FOLD FOLD

SUBSTANCE COMPLEX CARBOHYDRATE ROUGHAGE	**DIGESTED PRODUCTS** NOT DIGESTED	**WASTE PRODUCTS** COMPLEX CARBOHYDRATE ROUGHAGE
SUBSTANCE OXYGEN	**DIGESTED PRODUCTS** NOT DIGESTED	**WASTE PRODUCTS** WATER CARBON DIOXIDE
NUTRIENTS WATER	**DIGESTED PRODUCTS** WATER	**WASTE PRODUCTS** WATER

Figure SP 5.5.2(6) Nutrient strips

Name ______________________

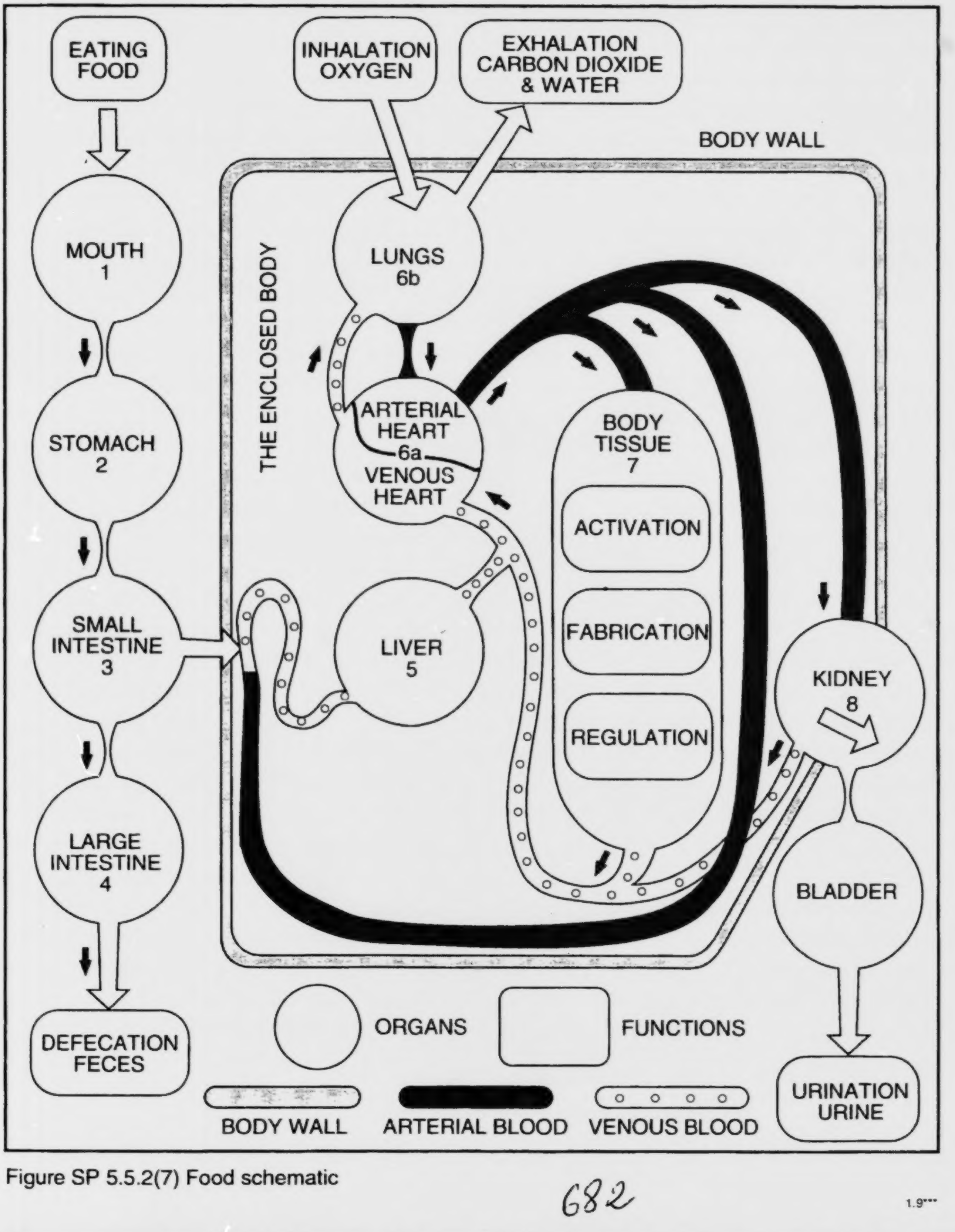

EATING FOOD
INHALATION OXYGEN
EXHALATION CARBON DIOXIDE & WATER
BODY WALL
MOUTH 1
THE ENCLOSED BODY
LUNGS 6b
STOMACH 2
ARTERIAL HEART
6a
VENOUS HEART
BODY TISSUE 7
ACTIVATION
FABRICATION
REGULATION
SMALL INTESTINE 3
LIVER 5
KIDNEY 8
LARGE INTESTINE 4
BLADDER
DEFECATION FECES
ORGANS
FUNCTIONS
BODY WALL
ARTERIAL BLOOD
VENOUS BLOOD
URINATION URINE

Figure SP 5.5.2(7) Food schematic

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ACTIVITY 5.5.3 FOOD LABELING

OBJECTIVES

The students
- Develop working definitions for RDAs, DVs, and U.S.RDAs.
- Develop a menu using foods represented in a collection of food labels.
- Develop a menu that meets the DV requirements and stays within the guidelines of the Food Guide Pyramid.

BACKGROUND

This activity is part of the nutrition sequence. To this point DASH students have been introduced to two systems for selecting foods to provide an adequate diet. First they were introduced to the three-group Activation, Regulation, Fabrication (ARF) system based on the *functions of foods.* Next they were introduced to the Food Guide Pyramid system, which is based on *nutrient characteristics of foods.* In this activity they are introduced to the new Daily Values system of food labeling, which gives information based on recommended dietary allowances or RDAs.

History

The United States Department of Agriculture (USDA) has introduced a new system for food labeling. It is very much like the older U.S.RDA system, with Daily Values (DVs) being quantitatively equivalent to the U.S.RDAs.

Nutrient Information

The nutritional information on the labels of canned and packaged goods includes a variety of things:
- The serving size.
- The number of kilocalories of energy that the nutrients will produce. The unit on the label is the nutritionist's Calorie, which is equal to the kilocalorie of the metric system.
- The number of grams of nutrients producing energy (fat, carbohydrate, and protein).
- The number of grams of sodium (mostly from table salt).
- The percentage of DVs of selected minerals and vitamins.

Table 5.5.3-1 Required and optional nutrient listings

REQUIRED NUTRIENT LISTINGS		
NUTRITION FACTS		
Serving Size	...	
Servings per Container	...	
Total Calories	...	
Calories from Fat	...	
NUTRIENT	**Amount/ Serving**	**DV***
Total Fat	... g	... %
Saturated Fat	... g	... %
Cholesterol	... mg	... %
Sodium	... mg	... %
Total Carbohydrate	... g	... %
Dietary Fiber	... g	... %
Sugars	... g	... %
Protein	... g	
Vitamin A		... %
Vitamin C		... %
Calcium		... %
Iron		... %
OPTIONAL NUTRIENT LISTINGS		
Thiamin (Vitamin B_1)		... %
Niacin		... %
Riboflavin		... %
Vitamin B Complex		... %

* Percent DVs are based on a 2000-Calorie diet. Some processors also give percent DVs based on a 2500-Calorie diet.

Table 5.5.3-2 Daily limits of selected nutrients

OPTIONAL NUTRIENT LISTING
Recommended Daily Limits of Selected Nutrients

NUTRIENT		**DIET 2,000 kcal**	**DIET 2,500 kcal**
Total Fat	Less than	65 g	80 g
Saturated Fat	Less than	20 g	25 g
Cholesterol	Less than	300 mg	300 mg
Sodium	Less than	2,400 mg	2,400 mg
Total Carbohydrate		300 g	375 g
Dietary Fiber		25 g	30 g

Ingredients

A list of the ingredients or food components is also required. The most abundant ingredient appears first. If a label lists BEEF STOCK, BEEF, TOMATOES, CARROTS, and so forth, the most abundant ingredient is a beef stock (chiefly water), then beef in some form, followed by tomatoes, then carrots and so on.

Kilocalorie

The energy content of a serving of food can be estimated from the carbohydrate, fat, and protein content in kilocalories (kcal).

- One gram of fat will produce 9 kcal of energy.
- One gram of carbohydrate will produce 4 kcal of energy.
- One gram of protein will produce 4 kcal of energy.

Estimating Energy Content

A food that contains 3 g of fat, 14 g of protein, and 14 g of carbohydrate will be reported as having 139 kcal of energy.

Fat Energy	=	3 g	x	9 kcal/g	=	27 kcal
Protein Energy	=	14 g	x	4 kcal/g	=	56 kcal
Carbohydrate Energy	=	14 g	x	4 kcal/g	=	56 kcal
Total						156 kcal

Excess Nutrients

Excess vitamins and minerals are excreted through the kidneys. Vitamins A and D can produce a toxic reaction if ingested in excess. Excess protein, fat, and carbohydrate intake can over time result in the building of excess fat tissue. Whether such a buildup occurs depends in part in the exercise habits and genetic makeup of individuals.

Food Labels
Have the students collect labels from canned and other processed foods. Have them write the name of the food that the label came from on the back.

Menu Planning
Menu planning is designed to acquaint the students with the new labeling system and to make them aware of the nutritional content of different processed foods. Unprocessed foods do not carry nutritional labeling. For information on these use standard nutrition books. Brief tables of the nutrient values of common foods can be found in almanacs.

STUDENT ROLES

Nutritionist
Householder

MATERIALS

menus
collection of food labels
Student Pages 5.5.1A THE FOOD GUIDE PYRAMID
5.5.3A RDA AND DV FACTS
5.5.3B MENU PLANNING

PRODUCTS

Completed Student Pages

PROCEDURES

1. **Have the students read the description of Daily Values and the RDA and U.S.RDA systems on Student Page 5.5.1A RDA and DV FACTS.**

   Ask such questions as these:

- What is meant by the term RDA? (Work for agreement that *RDA* refers to the recommended dietary allowance or the recommended amount of a nutrient that we need each day.)
- What is meant by the term Daily Value or *DV?* (Work for agreement that *DV* refers to the nutrient requirement or RDA of an average adult.)
- What is meant by a percentage of a DV? (Work to the idea that labels on foods show the percentage of the different DVs for nutrients contained in a serving.)
- What would be meant by 100% DV of Vitamin A? (Work for agreement that 100% DV of Vitamin A would mean that a person would receive 100% of the recommended amount of Vitamin A needed each day.)
- What would be meant by 50% DV of Vitamin A? (Work for agreement that 50% DV of Vitamin A would mean that a person would receive 50% of the recommended amount of Vitamin A needed each day by eating a serving of a particular food.)
- What is meant by the term U.S.RDA? (Work for agreement that *U.S.RDA* is an older term referring to the RDAs of average adults. *U.S.RDAs* still appear on vitamin and mineral supplements and some foods.)

2. **Have the students start a search for dietary information on food cans, wrappers, and packages and on vitamin and mineral supplements.**

   Have each student
   - Bring in 4 or more different food labels to develop a collection.
   - Record the kind of food the label was taken from on the back of the label if it does not appear on the front.

3. **Have the students work in groups and analyze the labels under your directed questioning.**

   Ask such questions as these:
   - Where did you find the nutritional information? (Work for agreement that it appears on the backs and side panels of cans, boxes, wrappers, and so forth.)
   - What information is given? (List the kinds of information on the board. See Background.)
   - Are there certain things that appear on most labels? (See Background.)

- In what units are serving sizes measured? (Usually in both English and metric units.)
- In what units are nutrient components measured? (In metric units.)
- What kinds of nutrients are presented in percentages of DVs? (Note that these are fat, saturated fat, cholesterol, carbohydrates, and the vitamin and mineral nutrients.)
- Fats produce 9 Calories (kcal) of heat per gram; carbohydrate and protein, 4 Calories (kcal) per gram. What is used to determine the total number of Calories in the food? (Have the students do calculations to find that the reported Calories (kcal) are the sum of Calories (kcal) values of carbohydrate, fat, and protein.)
- Food content is listed under "ingredients" in order of abundance with the most abundant component appearing first and the least abundant appearing last. How many find that water is one of the most abundant components of the foods in your containers? Why might this be so?)

4. **Have the students select a day's menu from their packaged and canned foods. Have them use the Food Guide Pyramid from Student Page 5.5.1A for the number of servings to use from each food group. The serving sizes from the package should be used. See Student Page 5.5.3B MENU PLANNING.**

Have the students
- Stay within the 2000-kcal range and use all the nutrients listed on the student page.

5. **Summarize the activity.**

Ask such questions as these:
- Were you able to get the suggested number of Calories (kcal) using the numbers of servings suggested by the Food Guide Pyramid?
- Were you able to get a full 100% DV of the vitamins listed? (If students were unable to get all the vitamins, point out that for most vitamins there is a safety factor of 33% extra in the vitamin category. Any unneeded excess will usually be removed from the bloodstream by the kidneys.)
- Were you able to get a full 100% DV of the minerals listed? (If students were unable to get all the minerals, point out that there is also a safety factor of 33% in the mineral category.)

- When might you eat a diet of canned and packaged foods such as this? (Some people may eat this type of diet daily; others, only on outings.)

EXTENSIONS

Have the students

- Make a collection of food labels and put the collection in the science center.
- Use the labels in preparing other menus.

DASH

Name ______________________

Date ______________________

STUDENT PAGE 5.5.3A RDA AND DV FACTS

1. **What are RDAs?**
RDAs are *Recommended Dietary Allowances.* They are recommendations for the amount of a nutrient a person should eat each day.

2. **Who made the recommendations?**
The recommendations were made by a panel of the Nutrition Board of the National Academy of Science.

3. **Who are the recommendations for?**
There are 15 different sets of recommendations—2 for infants, 3 for children, and 5 each for males and females age 11 and older.

4. **How many nutrients do the recommendations cover?**
They cover protein and 18 vitamins and minerals.

5. **What are U.S.RDAs?**
Because of the large number of values for RDAs, the U.S. Department of Agriculture has established a system of *average RDAs.* These standards are called the U.S. Recommended Daily Allowances. Notice that they are called “daily” rather than “dietary” allowances.

6. **How do these U.S.RDAs differ from the RDAs?**
U.S.RDAs are based on the *highest values* of the RDAs. In most cases the standard is set to the needs of the adult male, except in the case of iron, which is set by the adult female standard.

7. **How are U.S.RDAs used?**
Until mid-1994 they were used in labeling the nutrient content of packaged and canned foods. They are still used on labels for vitamin and mineral supplements.

Name________________________________

8. **What are the Daily Values (DVs) that now appear on food labels?**
These are recommendations for nutrients in a 2000-calorie diet. They correspond in part with the old U.S.RDA system.

9. **How do DVs and U.S.RDAs differ?**
DVs go beyond the older system and give guidance for the consumption of total fat, saturated fat, cholesterol, total carbohydrate, sugar, dietary fiber, and sodium.

10. **What are the guidelines for fat?**
The amount of fat should be no more than 30% of total calories. One gram of fat produces 9 kcal of energy. The total mass of fat can be calculated for a 2000-kcal diet as follows:

Total fat in grams = (Total kcal x 30%) ÷ 9 kcal/g

For example:

A 2000-kcal diet should contain no more than 67 g of fat.
Total fat in grams = (2000 x 0.30) ÷ 9 = 67 g
(The printed values round off the 67 to less than 65.)
A 2500-kcal diet should contain no more than 83 g of fat.
(The printed values are rounded to less than 80 g.)

11. **What are the guidelines for carbohydrate content?**
The total amount of carbohydrate should be between low (55%) and high (60%) of the total calories. One gram of carbohydrate produces 4 kcal of energy. The total mass of carbohydrate can be calculated for a 2000-kcal diet as follows:

Low carbohydrate in grams = (Total kcal x 55%) ÷ 4 kcal/g
High carbohydrate in grams = (Total kcal x 60%) ÷ 4 kcal/g

For example:

A 2000-kcal diet should contain between 274 g and 300 g of carbohydrate
Low carbohydrate in grams = (2000 x .55) ÷ 4 = 274 g
High carbohydrate in grams = (2000 x .60) ÷ 4 = 300 g

DASH

STUDENT PAGE 5.5.3B MENU PLANNING

Name ____________________

Date ____________________

Plan a day's menu using the following charts and nutrition data from packaged foods.

TABLE 5.5.3B-1 Bread, Cereal, Rice, and Pasta Group

	FOOD	NUMBER OF KCAL	GRAMS OF PROTEIN	% VITAMIN A	% VITAMIN C	% CALCIUM	% IRON	% FAT	% CARBO-HYDRATE	% SODIUM
BREAD, CEREAL, RICE & PASTA GROUP 6-11 Servings										
TOTAL										

Name______________________

TABLE 5.5.3B-2 Vegetable Group

	FOOD	NUMBER OF KCAL	GRAMS OF PROTEIN	% VITAMIN A	% VITAMIN C	% CALCIUM	% IRON	% FAT	% CARBO-HYDRATE
VEGETABLE GROUP 3–5 Servings									
TOTAL									

TABLE 5.5.3B-3 Meat, Poultry, Fish, Dry Beans, Eggs, and Nut Group

	FOOD	NUMBER OF KCAL	GRAMS OF PROTEIN	% VITAMIN A	% VITAMIN C	% CALCIUM	% IRON	% FAT	% CARBO-HYDRATE
MEAT, POULTRY, FISH, DRY BEANS,EGGS & NUT GROUP 2–3 Servings									
TOTAL									

Name________________________

TABLE 5.5.3B-4 Fruit Group

	FOOD	NUMBER OF KCAL	GRAMS OF PROTEIN	% VITAMIN A	% VITAMIN C	% CALCIUM	% IRON	% FAT	% CARBO-HYDRATE
FRUIT GROUP	1								
	2								
2–4 Servings	3								
	4								
TOTAL	5								

TABLE 5.5.3B-5 Milk, Yogurt, and Cheese Group

	FOOD	NUMBER OF KCAL	GRAMS OF PROTEIN	% VITAMIN A	% VITAMIN C	% CALCIUM	% IRON	% FAT	% CARBO-HYDRATE
MILK, YOGURT									
& CHEESE GROUP									
2–3 Servings									
TOTAL									

Name____________________________________

TABLE 5.5.3B-6 Fats, Oils, and Sweets Group

FATS, OILS & SWEETS GROUP *Use Sparingly*	FOOD	NUMBER OF KCAL	GRAMS OF PROTEIN	% VITAMIN A	% VITAMIN C	% CALCIUM	% IRON	% FAT	% CARBO-HYDRATE
TOTAL									

TABLE 5.5.3B-7 Totals by Food Group

TOTALS BY FOOD GROUP	NUMBER OF KCAL	GRAMS OF PROTEIN	% VITAMIN A	% VITAMIN C	% CALCIUM	% IRON	% FAT	% CARBO-HYDRATE
Bread, Cereal, Rice, & Pasta Group								
Vegetable Group								
Meat, Poultry, Fish, Dry Beans, Eggs & Nut Group								
Milk, Yogurt & Cheese Group								
Fruit Group								
Fats, Oils & Sweets Group								
GRAND TOTAL								

SP 5.5.1A
THE FOOD GUIDE PYRAMID

Name ____________________

Date ____________________

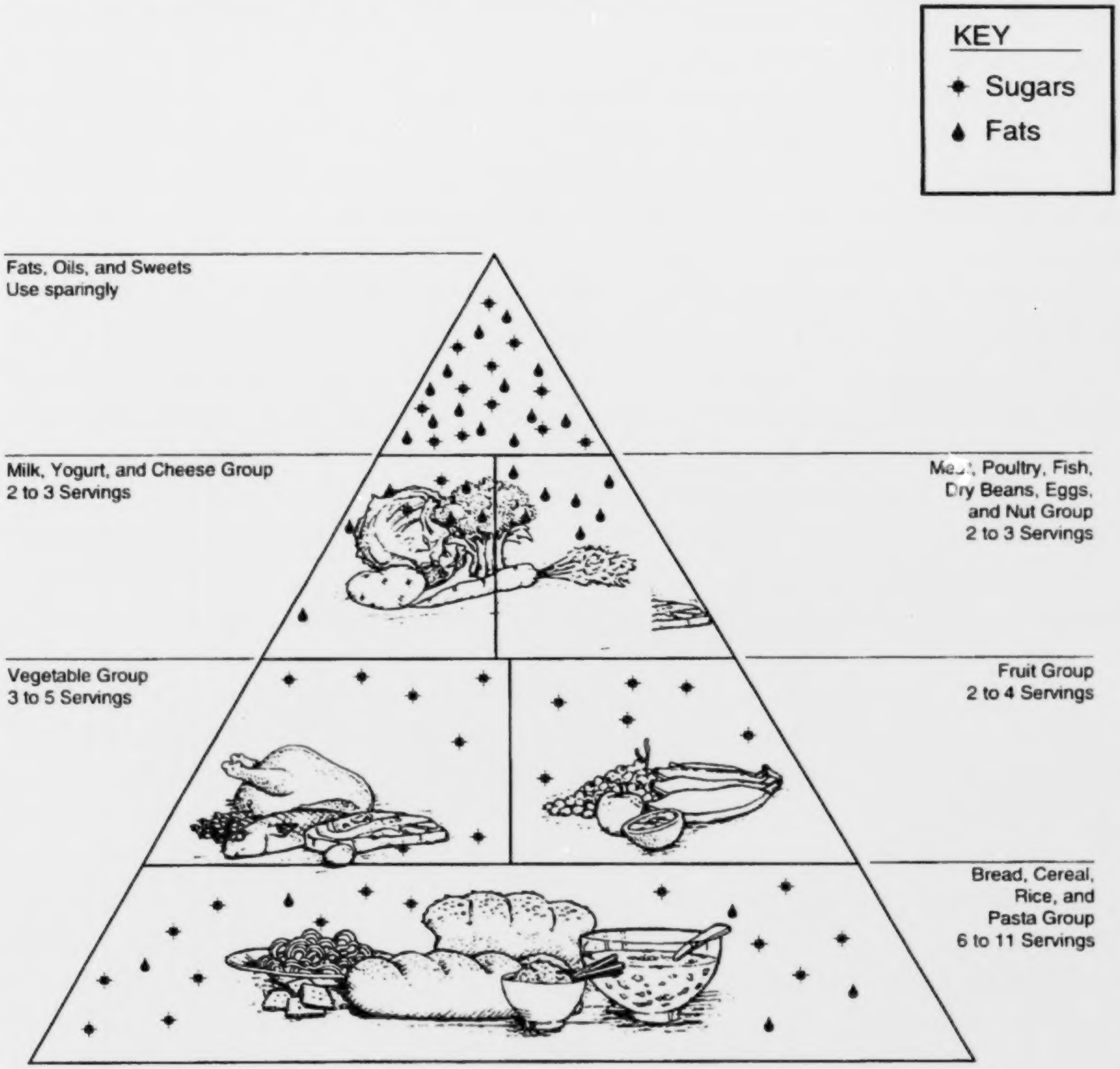

KEY
✦ Sugars
● Fats
Fats, Oils, and Sweets
Use sparingly
Milk, Yogurt, and Cheese Group
2 to 3 Servings
Meat, Poultry, Fish, Dry Beans, Eggs, and Nut Group
2 to 3 Servings
Vegetable Group
3 to 5 Servings
Fruit Group
2 to 4 Servings
Bread, Cereal, Rice, and Pasta Group
6 to 11 Servings

Figure SP 5.5.1A The Food Guide Pyramid

DASH

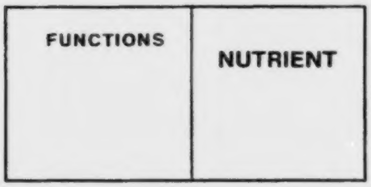
Name________________________

Date________________________

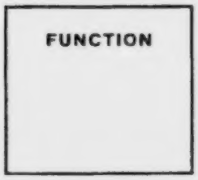
STUDENT PAGE 5.5.1B NUTRIENT CARD GAMES

1. **Assemble the cards for THE NUTRIENT CARD GAMES. There are three decks of cards with 48 cards in each deck**

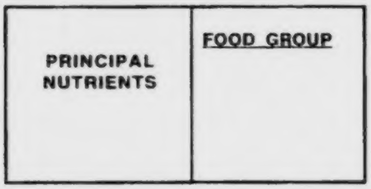
   - **NUTRIENT CARDS have a *nutrient* name on the face and a listing of the major *functions* of that nutrient on the back. Cut along the heavy lines. Fold along the dotted lines and tape the cards shut.**



   - **FUNCTION CARDS have a single nutrient *function* on their face and a blank on their back. Cut along the heavy lines.**



   - **FOOD GROUP CARDS have a *food group* on their face and the *principal nutrients* found in foods in the Food Group listed on their back. Cut along the heavy lines. Fold along the dotted lines and tape the cards shut.**



Name______________________________

2. Play the NUTRIENT-FUNCTION GAME using the following rules.

NUTRIENT-FUNCTION GAME

Number of players

2 to 4

Objective

To match **NUTRIENT CARDS** and **FUNCTION CARDS**.

Winner

The student who matches the most **FUNCTION** and **NUTRIENT CARDS**.

Play

- Separate the **NUTRIENT CARDS** from the **FUNCTION CARDS**, making two decks. Shuffle each deck separately.
- Place the **NUTRIENT CARD DECK** with the ***nutrient face up.***
- Deal 3 **FUNCTION CARDS** to each player with the ***blank side face up.***
- Place the remaining deck of **FUNCTION CARDS** next to the **NUTRIENT CARDS** with the ***blank side up.***
- Player 1 tries to match one Function card in the hand with the nutrient shown on the **NUTRIENT CARD** exposed on the deck.
- If successful in making a match, the player puts a **FUNCTION-AND-NUTRIENT CARD PAIR** in a personal pile. So all can see whether the match is correct or incorrect, the functions of the nutrient listed on the back of the **NUTRIENT CARD** are read aloud.
- If successful in making a match, the player replaces the first **FUNCTION CARD** in the hand with the card on the top of the **FUNCTION DECK.**
- If no match is made, the **NUTRIENT CARD** shown on the top of the **NUTRIENT DECK** is put on the bottom of the deck thus exposing a new **NUTRIENT CARD** for Player 2.
- Each successive player follows the same procedure as Player 1 until there are no more **FUNCTION CARDS** or no play is possible.

Name______________________________

3. **Play the NUTRIENT-FOOD GROUP GAME using the following rules.**

NUTRIENT-FOOD GROUP GAME

Number of players

2 to 4

Objective

To match **NUTRIENT CARDS** with the proper **FOOD GROUP CARDS.**

Winner

The student who is able to match the most cards.

Play

- Separate the **NUTRIENT CARDS** from the **FOOD GROUP CARDS**, making two decks. Shuffle each deck separately.
- Place the **FOOD GROUP DECK** so the **FOOD GROUP** is ***face up.***
- Deal 3 **NUTRIENT CARDS** to each player with the ***nutrient face down.***
- Place the remaining **NUTRIENT CARDS** next to the **FOOD GROUP CARDS** with the ***nutrient face down.***
- Player 1 tries to match a **NUTRIENT CARD** in the hand with the Food Group shown on the **FOOD GROUP DECK.**
- If successful in making a match, the player puts a **NUTRIENT CARD-AND-FOOD GROUP CARD PAIR** in a personal pile. So all can see whether the match is correct, the nutrients found in abundance in the food group are listed on the back of the **FOOD GROUP CARDS** and are read aloud.
- If successful in making a match, the player replaces the **NUTRIENT CARD** in the hand with another taken from the top of the **NUTRIENT DECK**.
- If no match is made, the **FOOD GROUP CARD** is put on the bottom of the deck and a new **FOOD GROUP CARD** is exposed for Player 2.
- Each successive player follows the same procedure as Player 1 until there are no more **FOOD GROUP CARDS** or no play is possible.

DASH

Name____________________________

Date____________________________

STUDENT PAGE 5.5.1C NUTRIENTS AND THEIR FUNCTIONS

Write in the name of the *nutrients* that match the *functions* listed.

1.		Helps carry oxygen in our body.
2.		Carries waste from the body in urine and sweat.
3.		Helps in blood clotting.
4.		Helps heal burns and other wounds.
5.		Is the second most abundant mineral in our body.
6.		Gives blood its red color.
7.		Dissolve and carry Vitamins A, D, E, and K.
8.		Helps start muscle contractions.
9.		Helps maintain our nervous system.
10		Helps dissolve all materials carried by the blood.
11.		Is the chief mineral in bones and teeth.
12.		Helps in growth of our body tissue.
13.		Is stored in the liver.
14.		Is an essential chemical in night vision.
15.		Helps in digestion of carbohydrates.

Name________________________________

16.		Is a product of the body's exposure to sunlight.
17.		Helps protect mouth, nose, throat, and lung tissue from infection.
18.		Helps maintain healthy skin, hair, and eyes.
19.		Makes up about 3% of our body weight.
20.		Helps maintain connective tissue—fat, cartilage, tendons, and bones.
21.		Makes up about 1% of our body weight.
22.		Helps in the use of proteins.
23.		Helps maintain our muscles
24.		Helps prevent breakdown of other vitamins.
25.		Are changed to fat for storage.
26.		Helps in use of calcium.
27.		Helps repair our body tissue.
28.		Helps prevent viral and bacterial infection.
29.		Are the chief source of our body's energy.
30.		Helps in energy storage.
31.		Build enzymes that regulate our body.
32.		Helps in use of phosphorus.
33.		Provide roughage (indigestible fiber) to aid digestion.
34.		Are the most concentrated source of energy in our body.
35.		Insulate our body from heat loss.

Name________________________________

36.		Make up about 2% of our body weight.
37.		Are the chief body-building material.
38.		Makes up about 65% of our body weight.
39.		Makes up about 14% of our body weight.
40.		Cover and protect vital organs.
41.		Are a reserve source of energy.
42.		Is the chief component of our body.
43.		Make up about 15% of our body weight.
44.		Is important for healthy bones.
45.		Help regulate protein and fat use in our body.
46.		Are the chief ingredient of hair, nail, muscle, and skin.
47.		Is the chief mineral in our body.
48.		Helps cool the body.

DASH

Name__________________________

Date___________________________

STUDENT PAGE 5.5.2 NUTRIENTS IN CELLS

1. **With your group cut out the strips representing nutrients in cells. See Figures SP 5.5.2(1–3). Assemble the strips into hexagon "cells" using Figures SP 5.5.2(4–6). Insert a triangle of complex carbohydrate roughage in each cell.**

2. **Describe what happens to the six nutrients as they are processed in the body.**

CARBOHYDRATES

____

____

____

____

____

____

____

FATS

____

____

____

____

____

____

____

Name______________________________

PROTEINS

MINERALS

VITAMINS

Name______________________________

WATER

Name________________________________

FACT SHEET: ORGANS AND DIGESTION

* * * * * * * * * *

THE MOUTH AND DIGESTION

- The mouth is a place of mechanical food breakdown and chemical digestion.
- Chewing crushes and tears apart food tissue.
- Chewing moistens food with saliva.
- Saliva makes the passage of food into the stomach easier.
- Saliva contains *ptyalin,* which works at digesting complex carbohydrates, particularly starch from grains.
- Crushed, moistened food is sent to the stomach by swallowing.

* * * * * * * * * *

THE STOMACH AND DIGESTION

- The stomach is about the size of two fists and is an elastic bag with many irregular ridges on its inside.
- The stomach is constantly contracting and expanding to mix food with gastric or digestive juices.
- One of the gastric juices in the stomach is hydrochloric acid, which produces a pH of about 1. (This is a very high acid concentration.)
- This hydrochloric acid is produced in the walls of the stomach.
- The hydrochloric acid kills most bacteria in food.
- Gastric juices begin digestion of protein.
- Gastric juices also clot milk.
- After 3–4 hours of constant churning, the contents of the stomach are a watery mixture like split pea soup called *chyme.*
- The chyme is sent on to the small intestine.

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Name____________________________

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THE SMALL INTESTINE AND DIGESTION

- The small intestine is connected to the stomach by a muscular valve called the *pyloric valve.*
- The small intestine is about 4 times as long as the person is tall and 2.5 to 4 cm in diameter.
- Bile from the liver enters the small intestine close to the pyloric valve.
- Bile helps break up fats and put them into solution.
- Digestive juices from the pancreas enter the small intestine at about the same place that the bile enters.
- Pancreatic juices help digest fats, proteins, and carbohydrates.
- Digestive juices from the intestinal wall help digest proteins and carbohydrates.
- Digestive juices release minerals and vitamins so they can be absorbed in the bloodstream.
- The small intestine is where nutrients are absorbed into the bloodstream.
- Between 95% and 99% of the proteins in food are broken down to amino acids and absorbed into the bloodstream.
- About 95% of the fat in food is directly absorbed into the bloodstream.
- About 80% of the carbohydrates in food are absorbed into the bloodstream as sugars.
- Between 80–90% of the vitamins and minerals are absorbed into the bloodstream.
- About 60% of the water from food, drink, and digestive juices is absorbed into the bloodstream.

* * * * * * * * * * *

Name______________________________

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THE LARGE INTESTINE AND DIGESTION

- The large intestine connects to the small intestine.
- The large intestine is 1–2 meters long and 5–8 cm in diameter.
- The large intestine is the place for storage of undigested food.
- Most of the remaining 40% of the water from food, drink, and digestive juices is absorbed into the bloodstream from the large intestine.
- Undigested materials, particularly complex carbohydrates, roughage, and bacteria are compacted into a stool that leaves the body in the process called *defecation*. Bacteria produce the gas that accompanies the stool.
- In times of illness the water-removal function of the large intestine may be reversed, and the stool may be liquefied for rapid removal.

* * * * * * * * * * *

THE LIVER AND ABSORBED NUTRIENTS

- Blood, carrying nutrients from the intestines, goes directly to the liver.
- The liver converts poisonous materials from the blood into non-poisonous materials in a process called *detoxification.*
- Much of the detoxified material goes into bile, which the liver pours into the small intestine.
- Alcohol is detoxified in the liver and converted to water and carbon dioxide.
- Sugar from carbohydrates is stored in the liver for a short time to supply energy between meals.
- Excess amino acid from protein is broken down into urea, which is extracted by the kidney.

* * * * * * * * * * *

Name________________________________

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THE HEART AND LUNGS

- Blood from the liver and the rest of the body is pumped by the heart to the lungs.
- In the lungs carbon dioxide and some water leave the blood and pass into the air.
- Carbon dioxide and water come from carbohydrates, fats, proteins, and other chemicals in the blood as they oxidize or burn to produce our body's energy.
- In the lungs oxygen from the air is taken into the blood.
- Oxygen-rich and nutrient-rich blood is pumped by the heart from the lungs on three major pathways:
    - Blood may go to the body tissues to carry out body processes.
    - Blood may go to the kidneys for further cleaning.
    - Blood may go back to the digestive tract to pick up more nutrients.

* * * * * * * * * *

THE KIDNEYS

- In the kidneys wastes are removed from the blood.
- Wastes include urea, excess dissolved minerals, and excess vitamins.
- Wastes are mixed with water and become urine.
- Urine is stored in the bladder until urination.
- We normally begin to feel the need to urinate when the bladder is about half full.
- We release between 1.5 to 2 liters of urine a day, depending on the temperature and the amount we drink.
- We normally get more of our water from foods and oxidation of nutrients than from drinks.
- Cleansed blood from the kidneys returns to the heart.

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Name______________________________

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THE BODY TISSUES

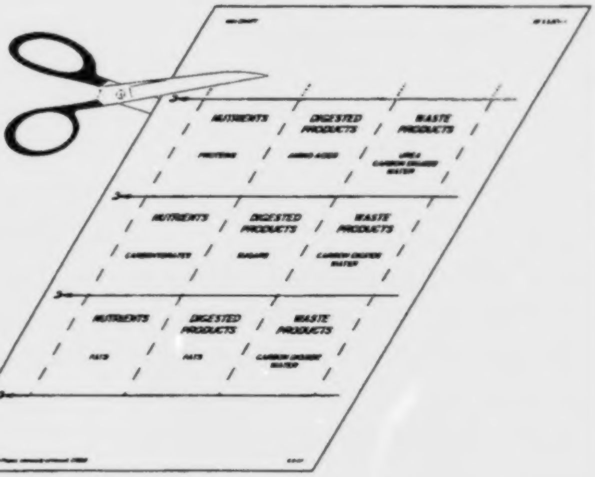
In the tissues of the body the nutrients and oxygen contents of the blood are used to carry out three basic functions:

- **Nutrients fabricate or build cells.**
    - *Fabrication* requires a proper mix of all six basic nutrients found in food.
    - In *fabrication* the six nutrients are reassembled into new cells.
    - *Fabrication* replaces injured or worn-out cells.
    - *Fabrication* permits the body to grow by building new cells.
- **Nutrients regulate or direct the operations or workings of cells.**
    - *Regulation* requires vitamins, minerals, and chemicals made by cells.
- **Nutrients activate the cells or produce the energy necessary to run them.**
    - *Activation* involves oxidizing or burning of carbohydrates, fats, and proteins to produce energy.
    - Burning nutrients requires oxygen, which is carried by the blood.
    - Burning forms carbon dioxide and water, which are released from the blood by the lungs. Water is also released by the kidneys and passes into the large intestine.
    - Cells usually burn carbohydrates.
    - Fats and proteins are burned mostly when nutrient carbohydrates are used up.
    - Excess carbohydrates are converted to fats, which are stored in fat cells.
    - Cells also produce waste products as they operate and wear out.
    - Cell wastes are released into the blood.
    - These wastes are made (detoxified) in the liver and removed from it as *bile* or from the kidneys as *urine*.

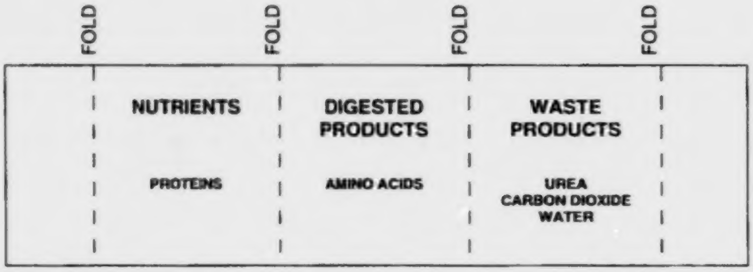
* * * * * * * * * * *

ILLUSTRATIONS

① Cut along path indicated by scissors. ✂


NUTRIENTS
DIGESTED PRODUCTS
WASTE PRODUCTS
PROTEINS
AMINO ACIDS
UREA
CARBON DIOXIDE
WATER
NUTRIENTS
DIGESTED PRODUCTS
WASTE PRODUCTS
CARBOHYDRATES
SUGARS
CARBON DIOXIDE
WATER
NUTRIENTS
DIGESTED PRODUCTS
WASTE PRODUCTS
FATS
FATS
CARBON DIOXIDE
WATER

② Fold on the dotted lines.


FOLD
FOLD
FOLD
FOLD
NUTRIENTS
DIGESTED PRODUCTS
WASTE PRODUCTS
PROTEINS
AMINO ACIDS
UREA
CARBON DIOXIDE
WATER

③ Form a triangle and hold with a paper clip.
Place clip on the side marked **WASTE PRODUCTS.**

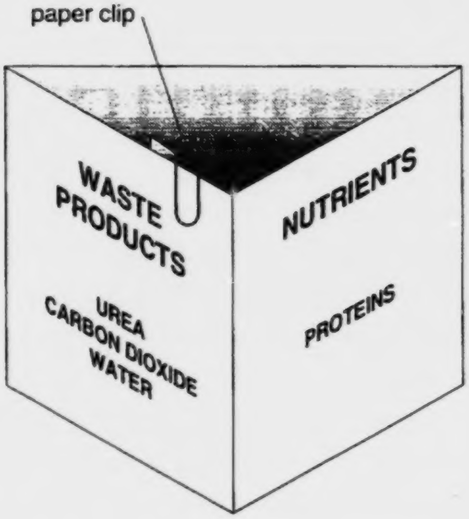

paper clip
WASTE PRODUCTS
UREA
CARBON DIOXIDE
WATER
NUTRIENTS
PROTEINS

Figure SP 5.5.2 (1) Assembling pieces for a nutrient cell

BEST COPY AVAILABLE

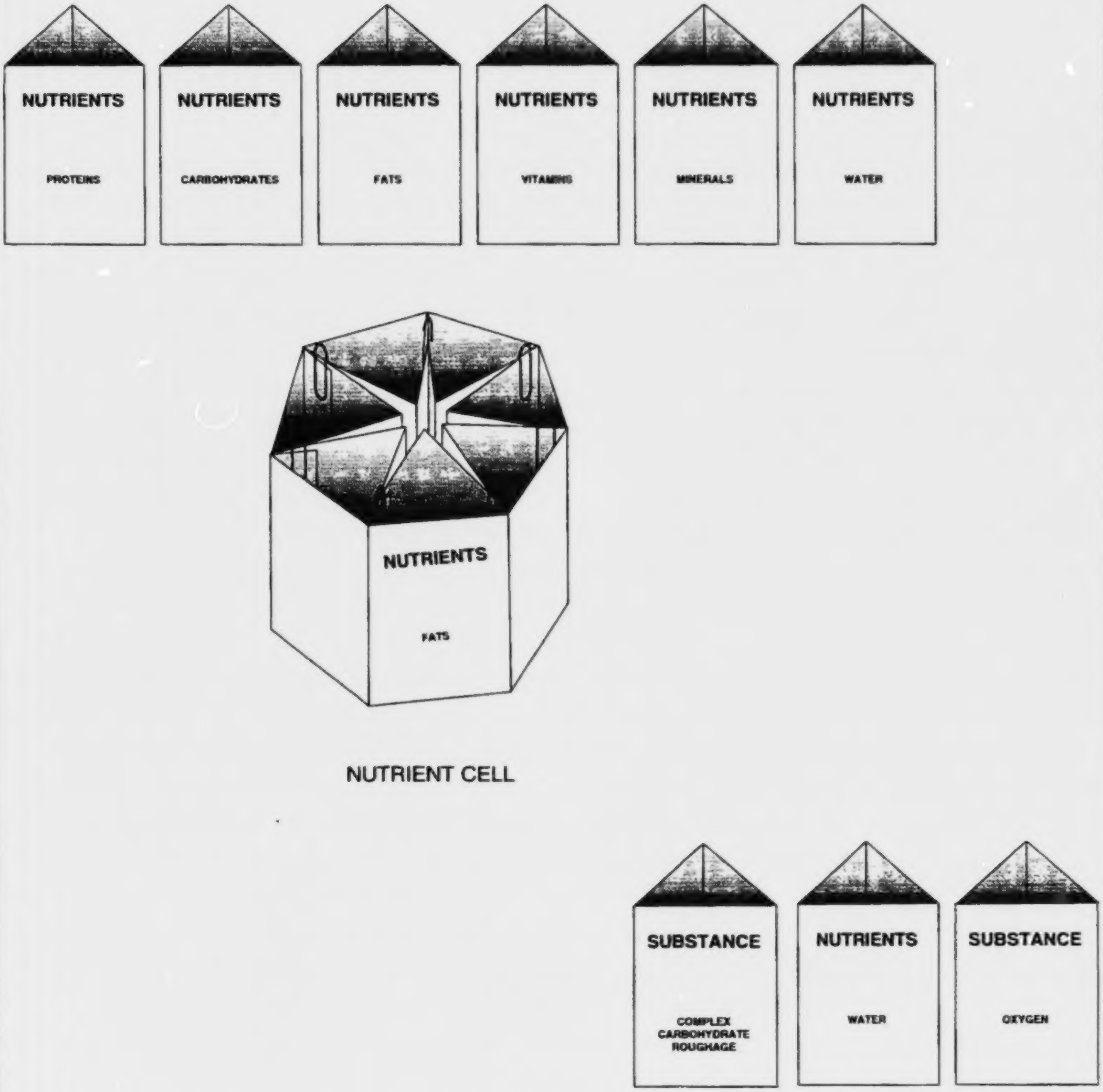

NUTRIENTS
PROTEINS
NUTRIENTS
CARBOHYDRATES
NUTRIENTS
FATS
NUTRIENTS
VITAMINS
NUTRIENTS
MINERALS
NUTRIENTS
WATER
NUTRIENTS
FATS
NUTRIENT CELL
SUBSTANCE
COMPLEX
CARBOHYDRATE
ROUGHAGE
NUTRIENTS
WATER
SUBSTANCE
OXYGEN

Figure SP 5.5.2(2) Assembling a nutrient cell

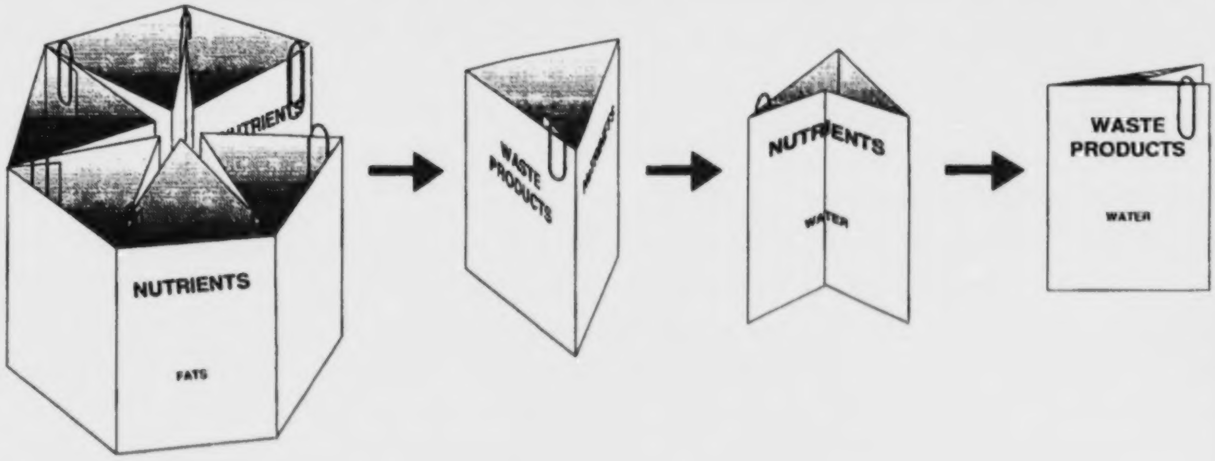

NUTRIENTS
NUTRIENTS
FATS
WASTE PRODUCTS
NUTRIENTS
WATER
WASTE PRODUCTS
WATER

Figure SP 5.5.2(3) Disassembling a nutrient cell

FOLD FOLD FOLD FOLD

NUTRIENTS PROTEINS	**DIGESTED PRODUCTS** AMINO ACIDS	**WASTE PRODUCTS** UREA CARBON DIOXIDE WATER
NUTRIENTS CARBOHYDRATES	**DIGESTED PRODUCTS** SUGARS	**WASTE PRODUCTS** CARBON DIOXIDE WATER
NUTRIENTS FATS	**DIGESTED PRODUCTS** FATS	**WASTE PRODUCTS** CARBON DIOXIDE WATER

Figure SP 5.5.2(4) Nutrient strips

FOLD FOLD FOLD FOLD

NUTRIENTS VITAMINS	**DIGESTED PRODUCTS** VITAMINS	**WASTE PRODUCTS** VITAMINS CARBON DIOXIDE WATER
NUTRIENTS MINERALS	**DIGESTED PRODUCTS** MINERALS	**WASTE PRODUCTS** MINERALS
NUTRIENTS WATER	**DIGESTED PRODUCTS** WATER	**WASTE PRODUCTS** WATER

Figure SP 5.5.2(5) Nutrient strips

FOLD FOLD FOLD FOLD

SUBSTANCE	**DIGESTED PRODUCTS**	**WASTE PRODUCTS**
COMPLEX CARBOHYDRATE ROUGHAGE	NOT DIGESTED	COMPLEX CARBOHYDRATE ROUGHAGE
SUBSTANCE	**DIGESTED PRODUCTS**	**WASTE PRODUCTS**
OXYGEN	NOT DIGESTED	WATER CARBON DIOXIDE
NUTRIENTS	**DIGESTED PRODUCTS**	**WASTE PRODUCTS**
WATER	WATER	WATER

Figure SP 5.5.2(6) Nutrient strips

Name ______________________

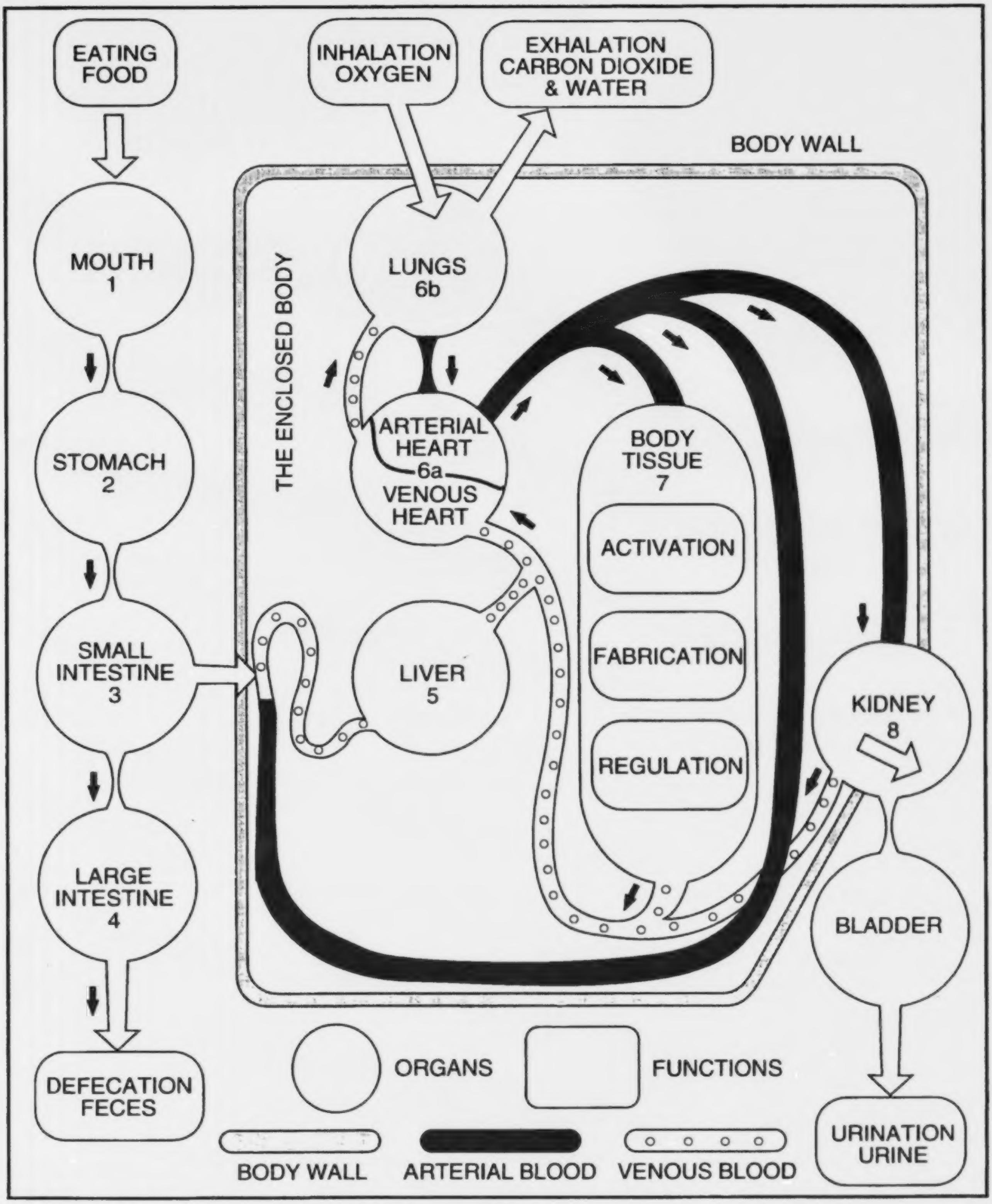

EATING
FOOD
INHALATION
OXYGEN
EXHALATION
CARBON DIOXIDE
& WATER
BODY WALL
THE ENCLOSED BODY
MOUTH
1
STOMACH
2
SMALL
INTESTINE
3
LARGE
INTESTINE
4
DEFECATION
FECES
LUNGS
6b
ARTERIAL
HEART
6a
VENOUS
HEART
LIVER
5
BODY
TISSUE
7
ACTIVATION
FABRICATION
REGULATION
KIDNEY
8
BLADDER
URINATION
URINE
ORGANS
FUNCTIONS
BODY WALL
ARTERIAL BLOOD
VENOUS BLOOD

Figure SP 5.5.2(7) Food schematic

DASH

Name ____________________________

Date ____________________________

STUDENT PAGE 5.5.3A RDA AND DV FACTS

1. **What are RDAs?**
   RDAs are *Recommended Dietary Allowances.* They are recommendations for the amount of a nutrient a person should eat each day.

2. **Who made the recommendations?**
   The recommendations were made by a panel of the Nutrition Board of the National Academy of Science.

3. **Who are the recommendations for?**
   There are 15 different sets of recommendations—2 for infants, 3 for children, and 5 each for males and females age 11 and older.

4. **How many nutrients do the recommendations cover?**
   They cover protein and 18 vitamins and minerals.

5. **What are U.S.RDAs?**
   Because of the large number of values for RDAs, the U.S. Department of Agriculture has established a system of *average RDAs*. These standards are called the U.S. Recommended Daily Allowances. Notice that they are called "daily" rather than "dietary" allowances.

6. **How do these U.S.RDAs differ from the RDAs?**
   U.S.RDAs are based on the *highest values* of the RDAs. In most cases the standard is set to the needs of the adult male, except in the case of iron, which is set by the adult female standard.

7. **How are U.S.RDAs used?**
   Until mid-1994 they were used in labeling the nutrient content of packaged and canned foods. They are still used on labels for vitamin and mineral supplements.

Name________________________________

8. **What are the Daily Values (DVs) that now appear on food labels?**
These are recommendations for nutrients in a 2000-calorie diet. They correspond in part with the old U.S.RDA system.

9. **How do DVs and U.S.RDAs differ?**
DVs go beyond the older system and give guidance for the consumption of total fat, saturated fat, cholesterol, total carbohydrate, sugar, dietary fiber, and sodium.

10. **What are the guidelines for fat?**
The amount of fat should be no more than 30% of total calories. One gram of fat produces 9 kcal of energy. The total mass of fat can be calculated for a 2000-kcal diet as follows:

    Total fat in grams = (Total kcal x 30%) ÷ 9 kcal/g

    For example:

    A 2000-kcal diet should contain no more than 67 g of fat.

    Total fat in grams = (2000 x 0.30) ÷ 9 = 67 g

    (The printed values round off the 67 to less than 65.)

    A 2500-kcal diet should contain no more than 83 g of fat.

    (The printed values are rounded to less than 80 g.)

11. **What are the guidelines for carbohydrate content?**
The total amount of carbohydrate should be between low (55%) and high (60%) of the total calories. One gram of carbohydrate produces 4 kcal of energy. The total mass of carbohydrate can be calculated for a 2000-kcal diet as follows:

    Low carbohydrate in grams = (Total kcal x 55%) ÷ 4 kcal/g

    High carbohydrate in grams = (Total kcal x 60%) ÷ 4 kcal/g

    For example:

    A 2000-kcal diet should contain between 274 g and 300 g of carbohydrate

    Low carbohydrate in grams = (2000 x .55) ÷ 4 = 274 g

    High carbohydrate in grams = (2000 x .60) ÷ 4 = 300 g

DASH

STUDENT PAGE 5.5.3B MENU PLANNING

Name ______________________

Date ______________________

Plan a day's menu using the following charts and nutrition data from packaged foods.

TABLE 5.5.3B-1 Bread, Cereal, Rice, and Pasta Group

	FOOD	NUMBER OF KCAL	GRAMS OF PROTEIN	% VITAMIN A	% VITAMIN C	% CALCIUM	% IRON	% FAT	% CARBO-HYDRATE	% SODIUM
BREAD, CEREAL, RICE & PASTA GROUP 6-11 Servings										
TOTAL										

Name____________________________________

TABLE 5.5.3B-2 Vegetable Group

	FOOD	NUMBER OF KCAL	GRAMS OF PROTEIN	% VITAMIN A	% VITAMIN C	% CALCIUM	% IRON	% FAT	% CARBO-HYDRATE
VEGETABLE GROUP 3–5 Servings									
TOTAL									

TABLE 5.5.3B-3 Meat, Poultry, Fish, Dry Beans, Eggs, and Nut Group

MEAT, POULTRY, FISH, DRY BEANS,EGGS & NUT GROUP 2–3 Servings	FOOD	NUMBER OF KCAL	GRAMS OF PROTEIN	% VITAMIN A	% VITAMIN C	% CALCIUM	% IRON	% FAT	% CARBO-HYDRATE
TOTAL									

Name______________________

TABLE 5.5.3B-4 Fruit Group

	FOOD	NUMBER OF KCAL	GRAMS OF PROTEIN	% VITAMIN A	% VITAMIN C	% CALCIUM	% IRON	% FAT	% CARBO-HYDRATE
FRUIT GROUP 2–4 Servings	1								
	2								
	3								
	4								
TOTAL	5								

TABLE 5.5.3B-5 Milk, Yogurt, and Cheese Group

	FOOD	NUMBER OF KCAL	GRAMS OF PROTEIN	% VITAMIN A	% VITAMIN C	% CALCIUM	% IRON	% FAT	% CARBO-HYDRATE
MILK, YOGURT & CHEESE GROUP 2–3 Servings									
TOTAL									

Name______________________________

TABLE 5.5.3B-6 Fats, Oils, and Sweets Group

FATS, OILS & SWEETS GROUP	FOOD	NUMBER OF KCAL	GRAMS OF PROTEIN	% VITAMIN A	% VITAMIN C	% CALCIUM	% IRON	% FAT	% CARBO-HYDRATE
Use Sparingly									
TOTAL									

TABLE 5.5.3B-7 Totals by Food Group

TOTALS BY FOOD GROUP	NUMBER OF KCAL	GRAMS OF PROTEIN	% VITAMIN A	% VITAMIN C	% CALCIUM	% IRON	% FAT	% CARBO-HYDRATE
Bread, Cereal, Rice, & Pasta Group								
Vegetable Group								
Meat, Poultry, Fish, Dry Beans, Eggs & Nut Group								
Milk, Yogurt & Cheese Group								
Fruit Group								
Fats, Oils & Sweets Group								
GRAND TOTAL								

DASH

GRADE FIVE
CLUSTER 6
Health and Safety

5.6.1 Growth Chart and Area Measurement
5.6.2 Tooth Chart
5.6.3 Safety Devices
5.6.4 Alcohol, Tobacco, and Drugs
5.6.5 Sexually Transmitted Diseases
5.6.6 Sexually Transmitted Disease Quiz
5.6.7 Tobacco Quiz
5.6.8 Smokers' Survey
5.6.9 Ex-smokers' Survey
5.6.10 Smoking Laws
5.6.11 Alcohol Quiz
5.6.12 Alcohol Laws
5.6.13 Chris's Story
5.6.14 The Parents' Story
5.6.15 Intoxication
5.6.16 Drug Laws

ACTIVITY 5.6.1
GROWTH CHART AND AREA MEASUREMENT

OBJECTIVES

The students
- Measure their height, weight, and hand and foot size.
- Compare their fifth-grade measurements with their measurements from previous years.
- Make predictions about their next measurements.

BACKGROUND

This activity is a companion to Activity 5.6.2 TOOTH CHART and can be done at the same time. It should follow Activity 5.10.1 LINEAR MEASUREMENT to give the students experience in area measurement.

Human Development

GROWTH CHART AND AREA MEASUREMENT is a continuation of a DASH K–6 project involving human growth and development. In this activity the students measure their height, weight, and hands and feet. They compare their measurements with those made in previous years by graphing class data. This gives them a sense of their own growth and an awareness of the variability of growth in people.

Timing

To make comparison with records from previous years easier, growth measurements should be done early in the school year if possible so that they will be about one year apart.

STUDENT ROLE

Physician

MATERIALS

scales
meterstick
Student Pages 5.6.1A GROWTH CHART
5.6.1B METRIC GRID
5.6.1C AREA MEASUREMENT

PRODUCTS

Growth charts

PROCEDURES

1. **Have the students measure their height, weight, and hand and foot size. Have them use Student Page 5.6.1A if the existing pages in their Science Record Book need replacement.**

   Have them record
   - Height in centimeters and inches.
   - Weight in kilograms and pounds.
   - Hand and foot size in number of square centimeters.

2. **Have the students compare their latest measurements with their measurements from the fourth grade.**

   Have them compute
   - Change in height in centimeters.
   - Change in weight in kilograms.
   - Change in hand and foot size in square centimeters. (Have them use the metric grid in Student Page 5.6.1B.)

3. **Have the students work in groups to graph the class height, weight, and hand and foot size since their first DASH class.**

4. **Discuss how the students are growing.**

   Ask such questions as these:
   - Are there any examples of decreases in height? In weight? (There may be decreases in weight, but unless a child has been physically injured, there should be no loss in height.)
   - Has everyone grown the same amount as everyone else? Why might this be so? (Get at the idea that we are all different in the way we grow.)
   - Which of the measurements show the greatest overall increase? (This will probably be weight.)
   - What do you think your dimensions will be the next time we measure them?

5. **Have the students read the background material in Student Page 5.6.1C AREA MEASUREMENT. Help them relate area measurement to linear measurement.**

EXTENSION

- Have the students compare their growth between grades 3 and 4 with their growth between grades 4 and 5.

DASH

Name____________________________

Date____________________________

STUDENT PAGE 5.6.1A GROWTH CHART

Record your height, weight or mass, and the area of your hand and foot. Use any Growth Chart already in your Science Record Book or if the pages are getting worn, transfer data from your Science Record Book to the table below.

		HEIGHT				WEIGHT/MASS			
GRADE	MO/YR	cm	*Change	in	*Change	lb	*Change	kg	*Change

		HAND AREA		FOOT AREA	
GRADE	MO/YR	cm^2	*Change	cm^2	*Change

*Change since last measurement

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SP 5.6.1B METRIC GRID

Name ______________________

Date ______________________

DASH

Name______________________

Date______________________

STUDENT PAGE 5.6.1C AREA MEASUREMENT

THE METRIC SYSTEM AND AREA MEASUREMENT

Once the meter and centimeter had been defined, it became possible to set standard units for measuring area. The *area* of a thing is the measure of its surface. A *surface* is what we feel when we pass our hands over something that is solid. It is usually the outside of things. A surface may also be the outer boundary of a liquid. For example, we swim at the surface of water.

The size of a surface is called an *area*. The most common units of area in the metric system that we will deal with are the *square centimeter* and the *square meter*. Figure SP 5.6.1C(1) shows a centimeter square. It is just what it sounds like, a square that measures 1 centimeter on each side. A square meter is a square measuring 1 meter on each side.

COMMON METRIC UNITS OF AREA	ABBREVIATIONS
square centimeter	cm^2
square meter	m^2
square kilometer	km^2

The raised *2* or superscript tells us we are using squares. We read "cm^2" as "centimeter squared" or "square centimeter."

Measuring Regular Geometric Surfaces

It is easy to measure the area of rectangular things using a piece of grid paper marked off in centimeter squares. In Figure SP 5.6.1C(2) Rectangle A has 6 centimeter squares in it, Rectangle B has 9, and Rectangle C has 12. Another method of finding area is to multiply the number of squares along the length of the rectangle by the number along the width.

AREA = LENGTH X WIDTH

Name ____________________

Sometimes a rectangle we are measuring does not completely cover all the centimeter squares that it overlays. When this happens, we can estimate the fraction or measure it. See Figure SP 5.6.1C(3).

Area of Irregular Surfaces

Surfaces may not be rectangular, but we can still get a very good estimate of their area using a grid. We simply place the grid paper over the surface, count the number of full squares, and then estimate the area covered by the others. See Figure SP 5.6.1C(4). Here there are 9 full centimeter squares and 6 that are about one-half a square centimeter.

The U.S. System of Area Measurement.

Area measurement in the English system in the United States is done the same way as it is in the metric system. Some common units of area are the square inch, the square foot, the square yard, and the square mile.

COMMON U.S. UNITS OF AREA	ABBREVIATIONS
square inch	in^2
square foot	ft^2
square yard	yd^2
square mile	mi^2

ILLUSTRATIONS

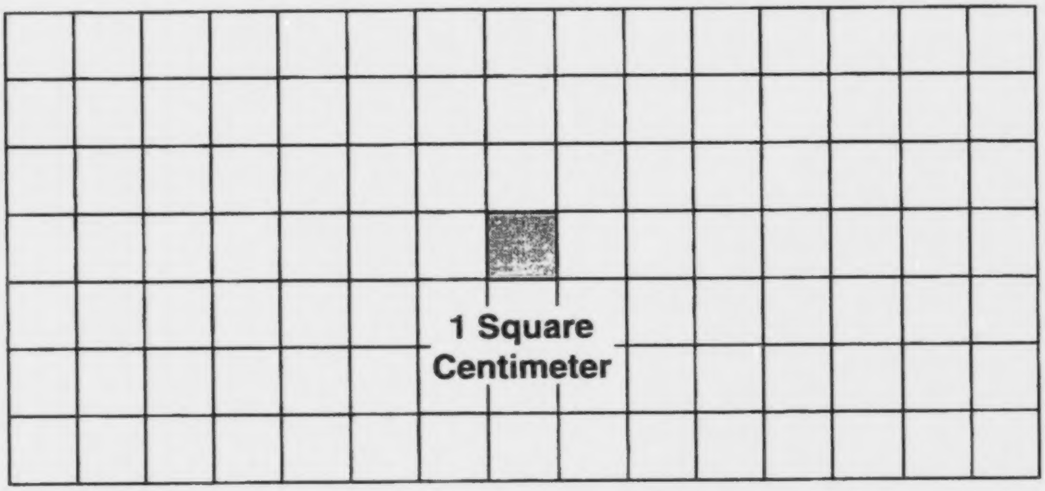
1 Square
Centimeter

Figure SP 5.6.1C(1) Square centimeter

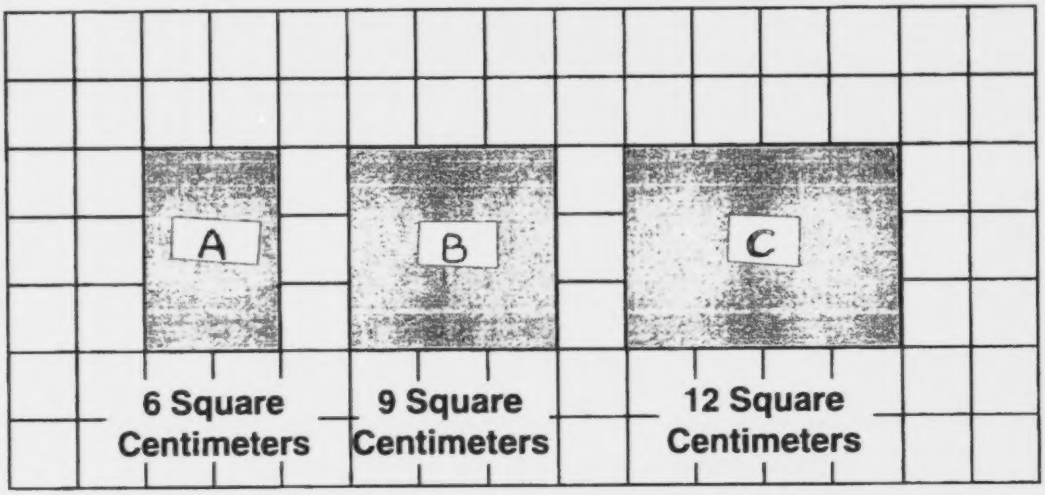
A
B
C
6 Square
Centimeters
9 Square
Centimeters
12 Square
Centimeters

Figure SP 5.6.1C(2) Use of a grid to measure the area of rectangles with whole numbers of square centimeters

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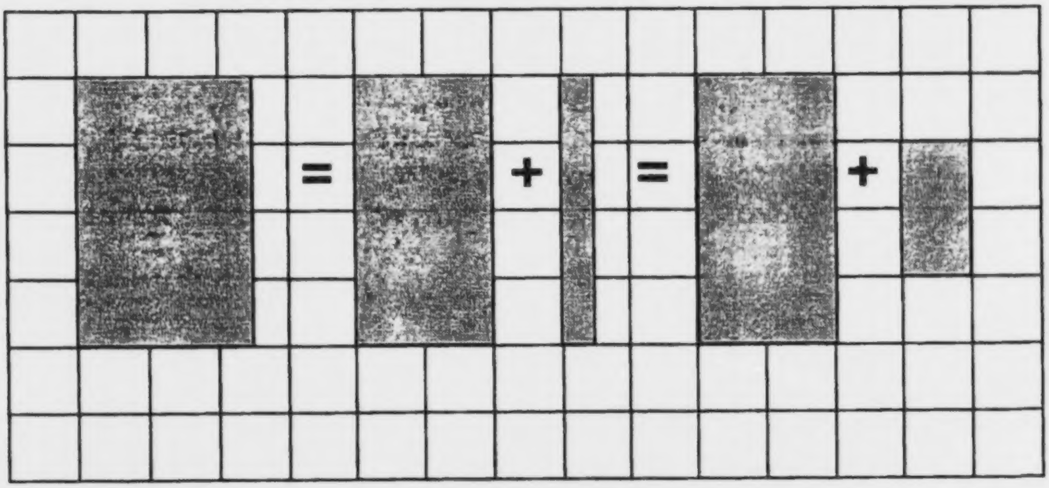

Figure SP 5.6.1C(3) Use of a grid to measure the area of a rectangle that does not have a whole number of centimeter squares

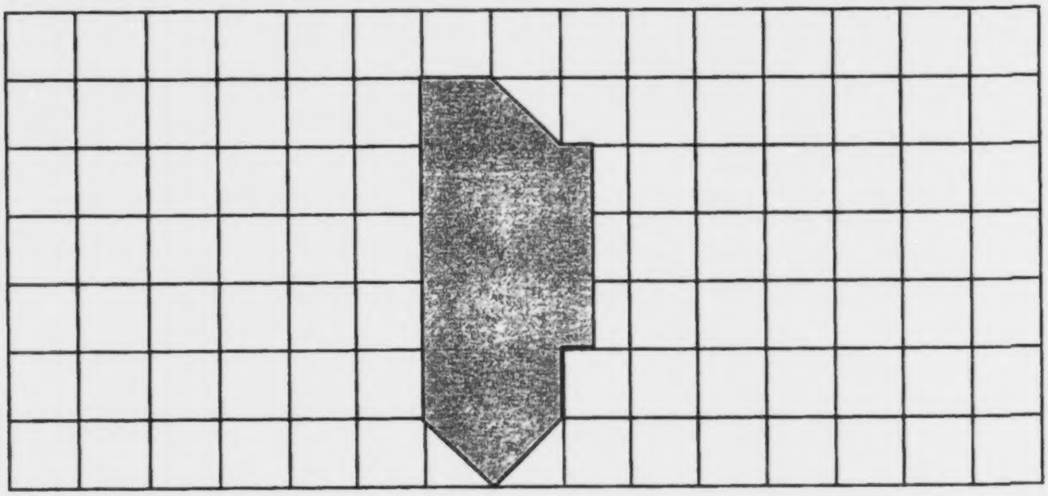

Figure SP 5.6.1C(4) Use of a grid to determine the area of an irregular surface

ACTIVITY 5.6.2 TOOTH CHART

OBJECTIVES

The students
- Continue keeping records of the number of teeth they have.
- Continue keeping records of the number of teeth they have lost.
- Continue keeping records of the number of cavities and fillings they have.

BACKGROUND

This activity is a companion to Activity 5.6.1 GROWTH CHART AND AREA MEASUREMENT. It continues a record-keeping project begun in kindergarten that involves keeping an ongoing inventory of tooth loss, new teeth, cavities, and fillings and other dental work. Keeping such longitudinal records gives students a sense of natural biological growth and change. It also gives insights into personal oral hygiene.

Dental Hygiene

At this point in their growth students will normally be well advanced in their development of adult teeth. This is the time to emphasize the need for daily personal attention to tooth hygiene because these new teeth can be replaced only by false ones.

STUDENT ROLE

Dentist

MATERIALS

mirrors
Student Page 5.6.2 TOOTH CHART

PRODUCTS

Completed Student Pages

PROCEDURES

1. **Introduce the annual tooth inventory to the class.**

Ask such questions as these:

- How many teeth do you think you have now?
- Has anybody lost teeth since your last count?
- Which tooth/teeth did you lose?

2. **Review the tooth inventory techniques with the students. Have them use Student Page 5.6.2 TOOTH CHART.**

Have them

- Review the names of the different kinds of teeth. (Molars, premolars, canines, and incisors.)
- Circle the picture on the tooth chart of each tooth that they don't find.
- Blacken in any gap due to a lost tooth.
- Put an *(X)* on all teeth that have cavities, fillings, or caps.

3. **Have the students verify each other's observations.**

4. **Collect class data.**

Ask such questions as these:

- How many teeth do you now have? (Have the students calculate the class average.)
- How many teeth have you lost since last you counted? (Have the students calculate the class average.)
- Have you gained any teeth this last year? (Have the students calculate the class average.)
- What is the size of your new teeth compared the old teeth? (Work for agreement that they are larger.)
- How many cavities have you now? How many did you have last year? (Have the students calculate the class average.)
- How many cavities do you have in old teeth? (Have the students calculate the class average.)
- How many cavities do you have in new teeth? (Have the students calculate the class average.)

5. **Summarize the activity and have the students make bar graphs of the class data.**

6. **Review good dental hygiene. Remind the students that their new teeth are the only ones they will get.**

7. **Discuss the following aphorism about flossing and brushing:**

**Twenty times up and twenty times down.
Brush your teeth all around
Then floss them carefully in between
To keep them bright and sparkling clean.**

EXTENSION

- Have the students research the makeup of a tooth and then draw and label a large diagram showing the interior of a tooth.

Name____________________________

Date____________________________

DASH

STUDENT PAGE 5.6.2 TOOTH CHART

Record the status of your teeth on the Tooth Chart below.

- Circle the picture of each tooth you cannot find.
- Blacken in any gap due to a lost tooth.
- Put an *(X)* on all teeth that have cavities, fillings, or caps.

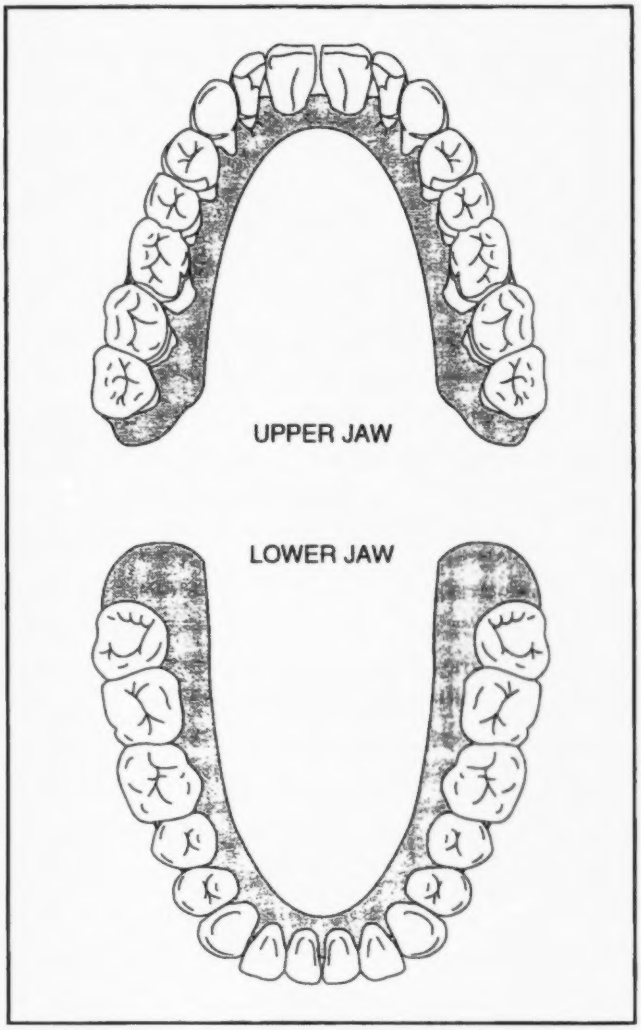

Figure SP 5.6.2 Tooth chart

SP 5.6.2–2

Name ______________________

TOOTH INVENTORY			
	MY COUNT	TOTAL CLASS COUNT	AVERAGE CLASS COUNT
Number of Teeth			
Number of Teeth Lost			
Number of Teeth Gained			
Number of Cavities			
Number of Cavities in Old Teeth			
Number of Cavities in New Teeth			

ACTIVITY 5.6.3 SAFETY DEVICES

OBJECTIVES

The students
- Invent and make raincoats.
- Invent and make protective aprons.
- Invent and make devices to handle hot or cold materials.
- Invent and make eye shields.

BACKGROUND

Safety is a major concern in DASH. To make the students aware of things that could be dangerous, the students are made responsible for identifying potential hazards in the classroom. They make their own protective gear and determine when such gear should be used and what its limitations are in protecting them. This, of course, does not take the primary responsibility for safety from the teacher, but it does provide many hands and eyes all working to identify and eliminate hazards.

NOTE: Special safety equipment is best produced when it is needed.

Safety Package

Items in the DASH safety system are
- The Safety Team—Two or more students should be appointed each week to watch for safety problems and inform the teacher when they think safety precautions should be taken.
- Garbage bag raincoats—DASH students begin making emergency raincoats from plastic garbage bags in kindergarten. The raincoats need not be made until the students need proper covering to work in the rain. The design should be the students' and utility should be stressed. The raincoats should be dried after use, folded, and stored for other emergency occasions.
- Garbage bag aprons—Every student should have a garbage-bag apron for work in the classroom and field. The design should be the students'. Utility should be stressed. The aprons should be cleaned after use and stored.
- Hot-cold pads and other devices—Pads and other devices invented by the students should be available for handling hot and cold materials. They should be cleaned and stored after use.
- Eye shields for protection from splashes—A design for an eye shield made from plastic bottles is shown in Figure 5.6.3. The students should

have the latitude to create shields that are comfortable but will prevent splashes from getting in their eyes.

STUDENT ROLES

Safety officer
Inventor
Safety-conscious worker

MATERIALS

20- to 30-gal plastic bags of good quality
cloths
heavy-duty twine
2-gal plastic jugs (milk, bleach, or other)
1-gal clear plastic soda bottles for window materials (Any heavy-duty clear plastic will do.)
duct tape
rubber bands
scissors
serrated knife or other cutter to make first cut in plastic (YOUR CONTROL)
Student Page 5.6.3 SAFETY EQUIPMENT

PRODUCTS

Raincoats
Aprons
Pads and other devices for handling hot and cold materials
Eye shields for protection from liquids
Completed Student Pages

PROCEDURES

1. Develop a concept map about classroom hazards.

Help the students include such things as these:

- Slippery floors.
- Hot things, cold things.
- Things that can get into our eyes.
- Things that can make us stumble.
- Sharp and pointed things in our desks.
- The way equipment is used.
- Playing instead of working.

- Improper use of sharp tools.
- Things that can fall over.
- Clothes that get wet, chilling us so we catch colds.
- Drains that get clogged so that water runs over the sink.
- Clutter that can make us slip.
- Blocked exits.
- Electrical plugs, cords, and equipment.

2. **Introduce the idea that we need to write safety rules to deal with hazards listed in the concept map.**

   Have the students
   - Make safety rules.
   - Post their safety rules.

3. **Announce that we need to have a Safety Team each week that will help remind us about safety. Establish a first Safety Team of two or three people. At the end of the week have the Safety Team report on what they have done during their time in office. Put the Safety Team on the Responsibility Chart.**

4. **When a project calls for covering clothes to prevent staining or wetting, have the students invent aprons.**

   Ask such questions as these:
   - What can we use to make aprons? (Work for agreement that the aprons should be made of plastic.)
   - What do we do with our aprons once we have used them? (Work for agreement that we clean and store them for later use.)

5. **When a project calls for working outside in the rain, have students who have no raincoats invent them.**

   Ask such questions as these:
   - What precautions do we need to take when we put a plastic bag over our heads? (Get at the need for air holes.)
   - What do we do with our raincoats once we have used them? (Work for agreement that we clean them and store them for later use.)

6. **When a project calls for handling hot or cold materials, have the students invent hot-cold pads or other handling devices.**

   Ask such questions as these:
   - What can we use to make devices to handle hot items? (Work for agreement that devices to handle hot items should be made of things that are not destroyed at the temperature of the item handled. Cloth or wood can be used for working with items of moderate temperature, but metal or ceramic materials should be used for handling extremely hot items.)
   - What do we do with our holders once we have used them? (Work for agreement that we clean them and store them for later use.)

7. **When a project calls for students to handle liquids that might get into their eyes, have them invent and make eye shields. Show them a prototype.**

   Make sure that the shields meet the following requirements:
   - The shields should have a wide-angle view. The plastic window should be wide and broad enough for the students to look in all directions.
   - The plastic window should be liquid-proof. No liquid should come in directly or around the sides.
   - All shields should be tested for waterproofing.
   - The shields should be secured so that they will not slip.
   - After use shields should be cleaned, inspected, and stored.

EXTENSIONS

Have the students
- Design other safety equipment including storage systems as needed.
- Write doggerel safety rules.

ILLUSTRATION

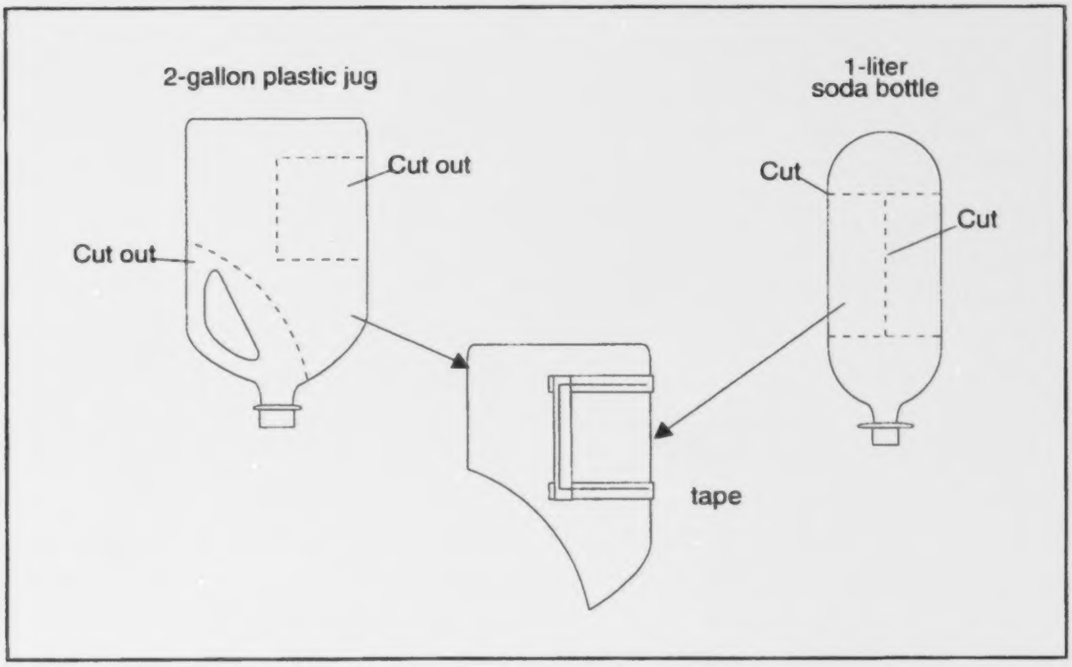
2-gallon plastic jug
Cut out
Cut out
1-liter soda bottle
Cut
Cut
tape

Figure 5.6.3 Design for an eye shield

DASH

Name________________________

Date________________________

STUDENT PAGE 5.6.3 SAFETY DEVICES

1. Draw your design for an eye shield to protect against liquids.

2. List your safety rules.

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ACTIVITY 5.6.4
ALCOHOL, TOBACCO, AND DRUGS

OBJECTIVES

The students
- Identify problems associated with alcohol, drugs, and tobacco.
- Collect news articles in scrapbooks to be used in analyzing alcohol, tobacco, and drug problems.

BACKGROUND

This activity continues the students' search for information about the worldwide use of alcohol, tobacco, and drugs. DASH 5 builds on the information gathered in DASH 4 and adds to the collection of articles dealing with losses and gains in society's struggle against these threats to health and well-being.

Again, the students make scrapbooks of newspaper and magazine articles about alcohol, tobacco, and drug problems. At the end of the year the scrapbooks should be saved in the library for further use in DASH 6. Summaries should be included with the articles.

Timing
This activity can be started anytime during the school year. To emphasize the importance of the activity, a good time to begin collecting is right after some noteworthy event in the community involving alcohol, tobacco, or drugs is in the headlines.

Data Base
There are several goals in this activity. The first is to develop a data base to help learn about the current status of these three socially sensitive health hazards.

Parent Involvement
The second goal is to involve the parents in helping the students interpret news articles. Newspapers are notoriously difficult to read with understanding, and the accounts of events that deal with alcohol, tobacco, and drugs are doubly so. This is because there is a special vocabulary used by newspapers in describing such topics. Most students will be unfamiliar with this vocabulary. In the beginning they will also probably be unaware

of the historical background, the "between the lines" stories that underlie the accounts. Involvement with interpretation of news articles provides a setting in which parents can comfortably speak to their children about tobacco, alcohol, and drugs.

Newspapers

The third goal is to help the students gain some degree of mastery over the newspaper as a source of information about the world. In this regard the investigation reinforces use of newspapers already underway in the posting of weather, unusual events, and scientific accounts on the Learning Calendar.

STUDENT ROLE

Researcher

MATERIALS

newspapers
3 scrapbooks
glue
Student Page 5.6.4 ALCOHOL, TOBACCO, AND DRUGS

PRODUCTS

Scrapbooks
Completed Student Pages

PROCEDURES

1. **Begin the year's study of alcohol, tobacco, and drugs by having the students check out of the library scrapbooks that were assembled in DASH 4. Have the students review their summaries.**

   Ask such questions as these:
   - What medical problems associated with alcohol, tobacco, and drugs did we find last year?
   - What other problems are there?
   - What successes have there been in preventing and treating these problems?

2. **Explain to the students that we need to keep on collecting information on alcohol, tobacco, and drugs and that we will again compile a class scrapbook on each topic.**

   Explain that we will regularly put the following into each scrapbook:
   - One or more articles dealing with the problems these health hazards produce. (Reports of deaths, medical reports of problems, the extent of use, and so forth.)
   - One or more articles dealing with the *positive* side of the situation. (Medical reports of treatments, enforcement successes, programs to fight addiction, and so forth.)
   - A summary of the articles.

3. **Have the students list the questions they have about alcohol, tobacco, and drugs that may be answered in articles during the year.**

   Help them include such questions as these:
   - What local problems do we now have with alcohol, tobacco, and drugs?
   - What are the local problems now with alcohol, tobacco, and drugs for elementary school students?
   - Why do people become "hooked" on alcohol, tobacco, and drugs?
   - Who is working to solve local alcohol, tobacco, and drug problems?
   - What can be done for people who become dependent on alcohol, tobacco, or drugs?
   - How much use of alcohol, tobacco, or drugs does it take before one becomes dependent or addicted?
   - How long before one has real health problems from using alcohol, tobacco, or drugs?
   - What can one do to avoid becoming involved in using alcohol, tobacco, and drugs?

4. **Have student groups collect articles for the class scrapbooks, summarize the articles, and report their findings to the class regularly.**

Have the students include in their reports such things as
- Where the article was found.
- What or whom the article was about.
- When the events described took place.
- Implications the events described have for us.
- How the article connects with what we have learned earlier.

5. **At the end of the year review the contents of the three scrapbooks with the class and have the students complete Student Page 5.6.4 ALCOHOL, TOBACCO, AND DRUGS.**

   Have the students
   - Report on the questions they asked at the beginning of the year and discuss any answers they have found.
   - List new questions.

6. **Have the students place the scrapbooks and summaries in the library for use in DASH 6.**

EXTENSIONS

Have the students
- Write essays on how alcohol, tobacco, and drug abuse are affecting their community.
- Invite health experts to answer their questions about alcohol, tobacco, and drugs.

DASH

Name________________________

Date________________________

STUDENT PAGE 5.6.4 ALCOHOL TOBACCO, AND DRUGS

1. List your questions about alcohol, tobacco, and drugs.

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2. List answers to your questions about alcohol, tobacco, and drugs.

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ACTIVITY 5.6.5
SEXUALLY TRANSMITTED DISEASES

OBJECTIVES

The students
- Identify problems associated with sexually transmitted diseases.
- Collect data to help understand the problems related to sexually transmitted diseases.

BACKGROUND

This activity begins a two-year search for information bearing on the worldwide concern about sexually transmitted diseases (STDs). In DASH 5 the students start to gather information in scrapbook form on the gains and losses in society's struggle against the threats to health and well-being posed by STDs.

Timing

The STD scrapbook can be started along with alcohol, tobacco, and drug scrapbooks. However, it is often better to wait until the collection of materials for these three less controversial scrapbooks has become routine before starting the STD scrapbook.

Home Involvement

As in Activity 5.6.4 ALCOHOL, TOBACCO, AND DRUGS, the students are working in a sensitive area filled with new vocabulary colored by a long history peppered with personalities, places, and customs. As a result, the students will need adult guidance, which again opens the door to interaction with the home.

The students make a class scrapbook containing newspaper and magazine articles about sexually transmitted diseases. At the end of each article they append a summary of the account. At the end of the school year the scrapbook should be placed in the library for use in DASH 6.

Professional Help

The field of knowledge about sexual transmitted diseases is growing at such a rapid rate that it is difficult in the extreme for the lay person to remain current. Students want immediate answers to their questions about STDs, and these are often best given by a health professional. In the early stages of the development of the scrapbook, it may be worthwhile to have a health professional join in the activity. Later visits can be arranged as needed. STDs present a deadly problem that must be taken seriously.

STUDENT ROLE

Health researcher

MATERIALS

newspapers
scrapbooks
glue
Student Pages 5.6.5 SEXUALLY TRANSMITTED DISEASES

PRODUCTS

Scrapbooks
Completed Student Pages

PROCEDURES

1. **Begin the activity by developing a concept map of the term *sexually transmitted diseases.***

   Help the students include such things as
   - Specific diseases. (Gonorrhea, syphilis, AIDS, and so forth.)
   - Path of transmission. (Through body openings, the sex organs, and blood transfusion.)
   - Drug-related problem of shared needles.
   - Potential cure. (Antibiotics for all but AIDS and other viral STDs. There is no known cure for AIDS at this time.)

2. **Tell the students that we need to collect information on sexually transmitted diseases to learn about their transmission, prevention, and treatment. To do this, we will be making a scrapbook of newspaper and magazine articles.**

Explain that we will put the following into a class scrapbook:

- One or more articles dealing with the *negative* side of the problems these health hazards produce. (Deaths, medical reports of problems, extent of use, so forth.)
- One or more articles dealing with the *positive* side of the situation. (Medical reports of treatments, techniques of prevention.)
- A summary of each article.

3. **Help the students list the questions they have about sexually transmitted diseases that may be answered in articles.**

Ask such questions as these:

- What are the long-term medical problems when the disease goes untreated?
- What are the symptoms?
- What are the treatments?
- What are ways of preventing the disease?

4. **Once each week have a different student group collect articles for the scrapbook, summarize the articles, and report their findings to the class.**

Make sure the students include such things as these:

- The origin of the article.
- What the article is about.
- Whom the article was about.
- When the events described took place.
- Implications the event has for us.
- How the article connects to what we have learned earlier.

5. **At the end of the year review the contents of the scrapbook with the students and have them complete Student Page 5.6.5 SEXUALLY TRANSMITTED DISEASES.**

6. **Have the class place the scrapbook and summaries in the library for use in DASH 6.**

EXTENSIONS

- Have the students make a collection of brochures, information pamphlets, and magazine articles on sexually transmitted diseases for a classroom library.
- Invite a professional health worker to discuss the students' questions.

DASH

Name_________________________

Date__________________________

STUDENT PAGE 5.6.5 SEXUALLY TRANSMITTED DISEASES

1. List your questions about sexually transmitted diseases.

2. List answers to your questions.

ACTIVITY 5.6.6
SEXUALLY TRANSMITTED DISEASE QUIZ

OBJECTIVES

The students
- Identify different kinds of sexually transmitted diseases and their prevalence.
- Identify symptoms, treatments, and probability of cure of sexually transmitted diseases.
- Develop an informational quiz about sexually transmitted diseases.

BACKGROUND

This activity is designed to follow Activity 5.6.5 SEXUALLY TRANSMITTED DISEASES. From their experience in collecting newspaper articles on sexually transmitted diseases (STDs) the students will have gained considerable background in the subject. What is now undertaken is a synthesis of their growing information base.

Considerations

This activity may be postponed for one or more years or alternate materials may be chosen to convey the message of the clear and present danger of STDs. *Exclusion of this STD activity or any other DASH health activity will* ***not*** *impair the overall DASH system.*

Your administration should be consulted before any STD curriculum is introduced in the classroom. The study of STDs is a sensitive issue that will require administrative support.

Data Sets

This activity uses a series of data sets built around questions and answers about STDs. Questions are organized around different kinds of STDs and their incidence, symptoms, treatment, and outlook. These data sets have been designed as part of the teacher materials to ensure control over their distribution.

The STD Data Sets deal with a subject whose information base is constantly evolving and will be modified over time. Care should always be taken that the content of any school activity matches the experience and needs of students.

Keep the idea before the students that it is the special role of the school to prepare them to live in the world of technology and science where research on disease is done. Our knowledge about disease and its prevention gives us considerable control over our lives when we act reasonably on that knowledge. Part of this knowledge is the special language of the newspaper and medical professions used in this activity.

Informational Quiz

To deepen their involvement in the study of STDs the students create an informational quiz that can be used with the public. The quiz should be designed to *give* information. It is suggested that the data sets be divided among groups and that each group be requested to come up with 5 to 10 true-false or multiple-choice questions that summarize their data set. They should use as many outside references as needed. New language should be defined and put into the Working Dictionary.

Testing the Quiz

The class should be the first test population for the quiz. Other groups to involve could be sixth graders who have had DASH or another fifth-grade class. Exchanging tests between DASH 5 classes will be a good reinforcement experience. Those taking the quiz should be asked to discuss the clarity of the questions.

STUDENT ROLES

Physician
Nurse
Public health worker

MATERIALS

Sexually Transmitted Disease Scrapbook
STD Data Sets as needed
Student Pages 5.6.6 SEXUALLY TRANSMITTED DISEASE QUIZ

PRODUCTS

Informational STD quiz
Completed Student Pages

PROCEDURES

1. **Review the students' present understanding of sexually transmitted diseases.**

   Ask such questions as these:
   - Why are we concerned about sexually transmitted diseases? (Get at the well-being and life-and-death issues connected with STDs.)
   - How can language be a problem in understanding STDs? (Work to the differences between the formal language of doctors, nurses, public health workers, and other professionals and the common language of the home and street.)
   - How well are people informed about STDs? (Get at the idea that there is much misinformation and ignorance about STDs.)
   - What would be a good way to show people what they do not know about STDs and at the same time inform them about such diseases? (Work to the idea of making an STD information-giving quiz.)

2. **Provide students with appropriate STD Data Sets. Help them organize in groups and construct 5–10 questions that summarize each data set. Have them devote a special part of their Working Dictionary for terms used in their quiz.**

   Help the students determine
   - The format of the quiz (true-false, multiple-choice, or other.)
   - The number of questions each group is to produce.
   - How they are going to check the quality of their questions. (Get at the need to check their questions within the class first.)
   - Who will take their quiz. (Have the students negotiate to exchange quizzes with another DASH 5 class or use the quiz with a sixth-grade class of students who have a background in DASH.)

3. **Have the class take the quiz, review the responses, and make needed changes in the quiz.**

4. **If possible arrange to have the students give the quiz to an outside group. Assist them as needed.**

   Help the students
   - Determine the background of their response group.
   - Give the quiz and provide the answers.

- Ask for a critique on the quality of their test.
- Take another fifth grade's quiz and then critique it.

EXTENSIONS

Have the students

- Ask the school nurse or a medical doctor to critique their quiz.
- Research and report on the human immune system.

STD DATA SETS

DATA SET 1
SEXUALLY TRANSMITTED DISEASE TERMS

- **WHAT IS A SEXUALLY TRANSMITTED DISEASE?**
  A *sexually transmitted disease or STD* is a disease that can be passed from one partner to another while having sex. Certain STDs, particularly those produced by viruses such as HIV and herpes, can be transmitted by the use of unsterilized drug needles and contaminated blood.

- **WHAT IS VD?**
  VD is an abbreviation for venereal disease. This is an older term used mostly to refer to the STDs syphilis and gonorrhea. "Venereal disease" is still used, but "sexually transmitted diseases" is now the preferred term because at least 20 different diseases that can be passed between partners during sex are known.

- **WHY DO WE WORRY ABOUT SEXUALLY TRANSMITTED DISEASES?**
  Infection by STDs often overwhelms the body's natural defenses and produces diseases that last a lifetime unless treated. Some STDs cannot be cured. Many can cause infertility and death.

- **WHAT IS MEANT BY THE TERMS *SEXUAL CONTACT* OR *HAVING SEX?***
  The terms *sexual contact* or *having sex* refer to any exchange of fluids from the penis or vagina.

- **WHAT IS VAGINAL SEX?**
  Vaginal sex refers to the entry of the penis into the vagina. This is reproductive sex, which delivers sperm to the uterus where sperm can meet and fertilize an egg released by an ovary.

- **WHAT IS ANAL SEX?**
  Anal sex refers to the entry of the penis into the anus. This is non-reproductive sex. Eggs cannot be fertilized.

- **WHAT IS ORAL SEX?**
  Oral sex refers to the use of the mouth with sex organs. This is non-reproductive sex. Eggs cannot be fertilized.

DATA SET 2
SEXUALLY TRANSMITTED DISEASE PREVENTION

- **HOW CAN STDs BE PREVENTED?**
  Abstinence and having a single uninfected sex partner are the only sure ways to prevent the sexual transmission of STDs. Considerable protection can be gained by covering sex organs with condoms during sex.

- **WHAT DO WE MEAN BY *ABSTINENCE*?**
  Abstinence means not having sex.

- **WHAT IS A *CONDOM* AND HOW DOES IT WORK?**
  A *condom* is a device made of rubber that can surround the penis or vagina and prevent the exchange of fluids between sex partners. It is usually the fluids that carry STDs.

- **HOW CAN ONE BE SAFE FROM INFECTED NEEDLES?**
  A hypodermic needle should be used only once. American hospitals follow this practice. Needles are cleaned with bleach and high-temperature sterilization in some other countries and reused. Even with this cleaning the danger of infection is still present.

- **HOW CAN ONE PREVENT INFECTION FROM STDs THAT ARE PASSED ON BY CONTACT WITH TOWELS, BEDDING, AND CLOTHING?**
  One should follow the normal practices of sanitation. Bedding and clothing should be washed regularly. Towels should not be shared, and hands should be washed before treating wounds or eating.

DATA SET 3
SEXUALLY TRANSMITTED DISEASE
KINDS OF DISEASES

- **WHAT KINDS OF ORGANISMS PRODUCE STDs?**
  Three kinds of organisms produce STDs: animal parasites, bacteria, and viruses.

- **WHAT ANIMAL PARASITES PRODUCE STDs?**
  Pubic lice are the most common animal parasites that cause STDs. They are often called "crabs" because they look like crabs. They are tiny flat arthropods visible with the unaided eye. They may grow up to 2 mm in length. They lay eggs called *nits* in the pubic hair where they hatch and spread to other hairy areas of the body.

  Trichomoniasis, often called "trich," is caused by another animal parasite, *trichomonas vaginalis.* This animal is a single-celled organism about pinpoint size that can live in the vagina for years before producing an infection.

- **WHAT ARE SOME EXAMPLES OF BACTERIAL STDs?**
  Gonorrhea, syphilis, and chlamydia are common examples of bacterial STDs. Most bacteria live in the fluids and spaces between body cells. They are very small and require a microscope that can magnify 1000 times or more to be seen. In our body they reproduce as fast as once every hour. In 24 hours one bacterium can divide to produce hundreds of millions of bacteria.

- **WHAT ARE VIRAL STDs?**
  Viral STDs are the most difficult to deal with medically because they cannot now be cured. Viruses are ultra-microscopic and can be seen only by using very high-powered microscopes that enlarge things hundreds of thousand of times. Viruses invade the cells of the body. Once in the cells, they often stay for long periods before they start to reproduce and destroy body tissue. For example, the HIV virus, which produces AIDS, may appear inactive for ten or more years before its damage is evident. There are three major viral STDs—genital warts, herpes, and HIV.

DATA SET 4
LICE AND TRICHOMONIASIS

- **HOW ARE PUBIC LICE CONTRACTED?**
  Pubic lice are contracted mainly through sexual contact, though they can also be transferred by contact with the bedding and hair of a person who has the lice.

- **WHAT ARE THE EVIDENCES OF PUBIC LICE?**
  The principal evidences of lice are itchiness and the visual presence of tiny crawling animals that look like crabs.

- **WHAT DO PUBIC LICE DO TO THE BODY IF THEY ARE NOT TREATED?**
  They can cause discomfort but usually no long-term damage.

- **WHAT IS THE TREATMENT FOR AN INFECTION OF PUBIC LICE?**
  Lice are killed by applying insecticide lotion to the body and hair. Bedding and towels should be washed in soapy water at least 140°F or 60°C. The entire family should be inspected and treated. These actions should cure the condition.

* * * * * * * * * * *

- **HOW COMMON IS TRICHOMONIASIS?**
  It is a common STD infection found in around 3,000,000 people in the United States each year.

- **HOW IS TRICHOMONIASIS CONTRACTED?**
  Trichomoniasis is contracted mainly by sexual contact, though it can be transferred by contact with towels and unwashed linen.

- **WHAT ARE THE SYMPTOMS OF TRICHOMONIASIS?**
  Males. Usually there are no symptoms. However, there may be inflammation of the urethra and pain in urination.
  Females. There may be no symptoms for many years. When symptoms do appear, they usually are itchiness of the vulva and a greenish-yellow, foamy discharge with an unpleasant odor from the vagina.

- **WHAT DOES TRICHOMONIASIS DO TO THE BODY IF IT IS NOT TREATED?**
  It can cause discomfort and in advanced stages, infertility.

- **WHAT IS THE TREATMENT FOR TRICHOMONIASIS?**
  Infection is normally treated with metronidazole, a specific drug to kill animal parasites. This is taken in pill form.

- **HOW EFFECTIVE IS THE TREATMENT OF TRICHOMONIASIS?**
  Usually it completely cures the infection. It does not reverse damage done to the urogenital system. Both sex partners should be treated at the same time to prevent reinfection.

DATA SET 5
GONORRHEA

- **HOW COMMON IS GONORRHEA?**
  Gonorrhea is one of the most common sexually transmitted diseases in the world. It is estimated that over 3,000,000 new cases are contracted each year in the United States alone.

- **HOW IS GONORRHEA CONTRACTED?**
  Gonorrhea is a sexually transmitted disease that can be contracted through all forms of sexual contact and through wet kissing and tainted blood. Gonorrhea can be passed on to a baby at the time of birth by an infected mother.

- **WHAT ARE THE SYMPTOMS OF GONORRHEA?**
  Males. Usually there is leakage of pus from the penis and a burning sensation when urinating. These symptoms appear 2–10 days after having sex with an infected partner. Not all infected males will show these symptoms.
  Females. About 60 percent have no symptoms. When there are symptoms, there will be leakage of a pasty fluid or discharge from the vagina and sometimes pain in urination.

- **HOW ARE BABIES INFECTED?**
  Babies are *not* infected during the pregnancy of an infected mother. However during birth they can be infected as they pass through the vagina.

- **WHAT DOES GONORRHEA DO TO THE BODY IF IT IS NOT TREATED?**
  Both *males* and *females* with untreated gonorrhea may become infertile or unable to reproduce due to infection in their urogenital system. Once in the bloodstream, the gonorrhea bacteria can cause arthritis and spread to the heart and brain causing death. *Babies* most commonly get an inflammation of the eyes that can cause blindness.

- **HOW CAN GONORRHEA BE TREATED?**
  Gonorrhea is normally treated and cured with antibiotics, particularly penicillin. When a penicillin-resistant strain of the bacteria is contracted, tetracycline or spectinomycin may be used. As a precaution, the eyes of newborn babies are treated at birth to ensure that they are not infected.

- **HOW EFFECTIVE IS TREATMENT?**
  Treatment is usually completely effective, but it does not protect against reinfection. Sex partners of an infected person must be notified and treated. Treatment does not restore damaged tissue.

DATA SET 6
SYPHILIS

- **HOW COMMON IS SYPHILIS?**
  Syphilis is much less common than gonorrhea. Some 150–200,000 persons are infected each year in the United States.

- **HOW IS SYPHILIS CONTRACTED?**
  Syphilis is a sexually transmitted disease that can be contracted from all forms of sexual contact, by wet kissing, and through tainted blood. Any open wound on the body can be a site for the entry of syphilis. Syphilis can be passed on to an unborn baby by an infected mother prior to birth. The disease often kills the baby.

- **HOW CONTAGIOUS IS SYPHILIS?**
  The risk of contracting syphilis in unprotected sex with an infected partner is very high. The disease is transmitted in about 1 out of 3 sexual contacts. There is a much higher infection rate when the partners have cuts or abrasions on the skin.

- **WHAT ARE THE SYMPTOMS OF SYPHILIS?**
  Untreated syphilis goes through four stages for both males and females:
  Stage 1. A painless red, wet sore called a *chancre* forms in the infected area—the penis, vulva, vagina, or other areas of contact 3–4 weeks after contact. Syphilis bacteria can get into any part of the body, even a finger or a hand, where there is an open cut. Lymph nodes in the region of the chancre swell. The chancre heals in 4–8 weeks. This is a period of high contagion.
  Stage 2. A rash develops 6–12 weeks after infection, but there is no itching. The rash may last from a week to months. There is often a headache, bone pains, fever, loss of appetite, and even loss of hair. After a year these symptoms spontaneously go away though the infection remains. This too is another period of high contagion.
  Stage 3. This is called the *latent period*. Here the person seemingly returns to normal health. This stage may last for several years or the rest of the person's life. This is a non-infectious phase of the disease. However, about one person in three will go into Stage 4.
  Stage 4. In this stage tumors can occur anyplace in the body. These destructive tumors often result in insanity and death.

- **HOW CAN SYPHILIS BE TREATED?**
  Syphilis is treated and cured by penicillin.

- **HOW EFFECTIVE IS TREATMENT?**
  Treatment is usual completely effective. Sex partners of an infected person must be notified. Treatment does not restore any body tissue already damaged.

DATA SET 7
CHLAMYDIA

- **WHAT ARE CHLAMYDIA?**
  Chlamydia are smaller than most bacteria but larger than viruses. They invade cells and reproduce within them as viruses do. Chlamydia produce one form of non-specific urethritis (NSU), an infection of the urethra. The urethra is the tube that carries urine from the bladder. In males it also carries sperm.

- **HOW COMMON IS CHLAMYDIA?**
  Chlamydia infects over 10 percent of all females of childbearing age in the United States.

- **HOW IS CHLAMYDIA CONTRACTED?**
  Chlamydia is transmitted through reproductive sex.

- **WHAT ARE THE SYMPTOMS OF CHLAMYDIA?**
  Males. The infection is usually symptomless. However, there may be a clear or milky discharge from the penis, pain in urination, and swelling of the testes.
  Females. The infection is usually symptomless, though there may be a discharge from the vagina and painful urination. In long-lasting infections there may be pain and sickness during sex.

- **WHAT DOES CHLAMYDIA DO TO THE BODY IF IT IS NOT TREATED?**
  In both males and females untreated chlamydia can lead to sterility.

- **HOW IS CHLAMYDIA DETECTED?**
  In 1993 a test on urine was devised that allows quick diagnosis of chlamydia.

- **HOW CAN CHLAMYDIA BE TREATED?**
  Treatment is with antibiotics that will cure the condition.

- **HOW EFFECTIVE IS THE TREATMENT?**
  The treatment is usually completely effective in curing the disease. However, the treatment does not restore any body tissue that has been destroyed by the disease. It will not restore fertility where it has been lost.

DATA SET 8
GENITAL WARTS

- **WHAT ARE THE SYMPTOMS OF GENITAL WARTS?**
  Genital warts are white cauliflower-shaped growths that appear on or around the organs involved in sex. They can be the size of a pinhead or larger than a dime. Warts appear 1 to 18 months after infection.

- **HOW COMMON ARE GENITAL WARTS?**
  It is estimated that 500,000 people in the United States get genital warts every year. Remember that once infected, one has the virus for life.

- **HOW ARE GENITAL WARTS CONTRACTED?**
  Genital warts are contracted through sex. They appear in the area of the organs involved.

- **WHAT DO GENITAL WARTS DO TO THE BODY IF THEY ARE NOT TREATED?**
  In both male and females the warts will spread and continue to grow larger if they are not removed.

- **HOW CAN GENITAL WARTS BE TREATED?**
  Genital warts can be removed by surgery, certain chemicals, and freezing with liquid nitrogen.

- **HOW EFFECTIVE IS THE TREATMENT?**
  Removal slows the growth of the warts, but they tend to reappear. There is no cure for the disease. Females who have genital warts have a much higher rate of cancer of the cervix than those who are not infected.

DATA SET 9
HERPES

- **WHAT ARE THE SYMPTOMS OF GENITAL HERPES?**
  The organs involved in sex develop a painful rash, itching, burning, and small blisters within 1 to 3 weeks after sex with an infected partner.

- **HOW COMMON IS GENITAL HERPES?**
  It is estimated that 20,000,000 people in the United States have genital herpes.

- **HOW IS GENITAL HERPES CONTRACTED?**
  Herpes can be contracted from all forms of sexual contact. It can also enter the bloodstream through any open wound.

- **WHAT DOES HERPES DO TO THE BODY?**
  In both *males* and *females* genital herpes blisters burst and leave an open sore that heals in 2 to 3 weeks. During this time lymph nodes swell and there may be a fever. Urination may be painful. Though people retain the virus, about half of those who have the infection never have another attack. The remaining group get recurring attacks 4 to 5 times a year.

- **HOW CAN HERPES BE TREATED?**
  A doctor can prescribe medication that will reduce the pain and discomfort.

DATA SET 10
HIV

- **WHAT IS HIV?**
  HIV is an abbreviation for the *human immunodeficiency virus*. This virus attacks the body's immune system. Our immune system involves the white cells in our blood that fight off invading disease organisms. HIV attacks a particular kind of defense cell called the *T-4 lymphocyte*. Without T-4 lymphocytes the immune system cannot fight off many bacterial and virus invaders. An HIV infection becomes the disease *AIDS* when the number of T-4 lymphocytes is reduced to a point where they can no longer fight off diseases. HIV infection eventually produces AIDS.

- **HOW COMMON IS HIV?**
  It is estimated that by the year 2000 some 3,500,000 people in the United States will have contracted HIV. Many will have died.

- **HOW IS HIV CONTRACTED?**
  HIV can be contracted through vaginal, anal, or oral sex, blood transfusion, and the sharing of infected needles. Babies may contract the disease from an infected mother while they are in the uterus.

- **HOW CONTAGIOUS IS THE HIV VIRUS?**
  HIV is not a highly contagious disease. It is not contracted by touching an HIV or AIDS patient. It is not contracted from sneezing, hand shaking, sharing food, bedding, or handling things an HIV-infected person touches.

- **HOW SOON AFTER CONTRACTING HIV CAN ONE TRANSMIT THE VIRUS?**
  It is possible for a person to infect another immediately after his or her own infection or anytime after that. The infectious state remains for the lifetime of the person.

- **WHAT ARE THE SYMPTOMS OF HIV?**
  Shortly after infection there will be short-lived symptoms of tiredness, a fever, swollen lymph nodes, and weight loss. These symptoms go away and a person may live for many years without further complications.

- **WHAT DOES HIV DO TO THE BODY?**
  The HIV virus attacks T-4 lymphocytes in the bloodstream. Without T-4 lymphocytes the body is defenseless against many viral and bacterial infections.

DATA SET 11
AIDS

- **WHAT IS AIDS?**
  AIDS is an abbreviation for the disease *acquired immune deficiency syndrome*. AIDS is the terminal or death-producing condition that exists when the HIV has destroyed the body's natural T-4 lymphocyte defense system.

- **HOW COMMON IS AIDS?**
  Between 4 and 10 percent of all the people infected with HIV will develop the terminal condition of AIDS each year.

- **WHEN IS AIDS DIAGNOSED?**
  AIDS is diagnosed when a person starts contracting infections the body cannot defend against. Common companion diseases to AIDS are tuberculosis, shingles, other bacterial and viral diseases, and cancer. These diseases kill the person with AIDS, not the HIV virus itself.

- **HOW CAN AIDS BE TREATED?**
  There is no drug or other treatment that removes HIV from the body. Anti- viral drugs and drugs that attack specific infections can be used to prolong the life of the AIDS patient.

DASH

Name_______________________

Date_______________________

STUDENT PAGE 5.6.6
SEXUALLY TRANSMITTED DISEASES QUIZ

1. List your quiz questions about sexually transmitted diseases.

2. List the answers to your quiz.

ACTIVITY 5.6.7 TOBACCO QUIZ

OBJECTIVES

The students
- Take an information-giving quiz to better understand the history of tobacco use.

BACKGROUND

This is the second in a sequence of activities about tobacco, alcohol, and drugs. It should follow Activity 5.6.4 ALCOHOL, TOBACCO, AND DRUGS and precede Activities 5.6.8 SMOKERS' SURVEY and 5.6.9 EX-SMOKERS' SURVEY. Students are often confused to find that both tobacco and alcohol are drugs that pose a definite health hazard but are not considered illegal for sale to adults. The Tobacco Quiz helps put the history of tobacco into perspective.

In this activity the students take an information-giving quiz and then discuss each item.

Currency of the Issue

As we approach the new century, the U.S. government and the tobacco industry are resolving the issue of liability for tobacco's damage to health. Newspaper accounts of legal settlements will make the stuff of good class discussion, reinforcing the need for constant research and the need for public awareness about health hazards.

STUDENT ROLE

Historian

MATERIALS

Student Page 5.6.7 TOBACCO QUIZ

PRODUCTS

Completed Student Pages

PROCEDURES

1. Introduce the activity by challenging the students to answer the questions found in Student Page 5.6.7 TOBACCO QUIZ. Encourage them to guess if they do not know the answers. Read the questions aloud so that there is no air of testing.

2. Go over the quiz, sharing the information given below.

THE TOBACCO QUIZ

1. **Tobacco first came from**
   a) Asia c) Africa
   b) Europe d) America

   d. Tobacco was brought to Europe by Columbus from his first voyage to America.

2. **Tobacco was first introduced as medicine.**
   True False

   True. Tobacco was used to treat toothaches and insect and snake bites and to reduce hunger pains.

3. **In the United States tobacco is the most profitable major crop per acre.**
   True False

   True. Wheat yields about $100 per acre, corn about $200 per acre, and tobacco about $3,200 per acre. (1995 prices)

4. **The United States is the world's largest exporter of tobacco.**
   True False

   True. Over 75 percent of our domestic crop is sold overseas.

5. **The United States is the world's largest producer of tobacco.**
   True False

   False. China is the largest producer of tobacco. It produces over 2 million tons per year. The United States is the second largest producer with about half a million tons per year.

6. **When was tobacco first recognized as a health hazard by the U.S. government?**
a) 1832 b) 1864 c) 1932 d) 1964 e) 1984

d. In 1964 the Surgeon General of the United States identified smoking as a threat to human health.

7. **What diseases were first identified with use of tobacco?**
a) heart disease
b) emphysema
c) lung cancer
d) bronchitis
e) peptic ulcers

b. and d. The first diseases identified were emphysema and bronchitis. All the other diseases listed have since been found to be associated with tobacco use.

8. **When was tobacco advertisement first banned from radio and TV?**
a) 1832 b) 1864 c) 1932 d) 1964 e) 1984

e. It was first banned in 1984.

9. **Tobacco is a major source of tax revenue in the United States.**
True False

True. Tobacco generates about 10 billion dollars in tax revenue a year.

10. **Tobacco is a major source of employment in the United States**
True False

True. The tobacco farming employs some 180,000 farm families. The manufacturing industry employs some 60,000 people.

11. **What is the legal age for smoking in different states?**
a) Varies b) 18 c) 21

a. The legal age of smoking varies.

12. **Tobacco use is addictive.**
True False

True. After consistent use for several weeks or months the smoker suffers withdrawal symptoms when trying to stop smoking. Withdrawal symptoms are evidence of an addiction. Tobacco is one of the most addictive drugs available today.

13. **Smoking by expectant mothers is a health hazard for unborn babies.**
True False

True. The U.S. Surgeon General's warning refers to the increased risk of infant mortality and low birth weight.

14. **When used by humans all forms of tobacco pose a health hazard.**
True False

True. All smoking tobacco, snuff, and chewing tobacco have health hazards connected with them.

15. **Smoking is not only dangerous to SMOKERS but also to those who breathe secondhand smoke.**
True False

True. This is the reason most states have laws governing where one can smoke.

16. **Less than one-third of the adult United States population smoke regularly.**
True False

True. The largest group is in the 30–to-40-year range.

17. **There has been a steady decrease in the number of cigarettes smoked per person in the United states since 1982.**
True False

True. The number has decreased each year since 1982.

3. Discuss the quiz.

Ask such questions as these:

- Why do you think it took till 1964 for the government to decide that cigarettes were bad for our health? (Work to the ideas that it took a long time to collect the data and that this kind of health research needed is relatively new.)
- What might account for the tobacco industry's fight against rules restricting the use of tobacco? (Get at the issue of financial gain.)
- Why should non-smokers be protected? (Explore the idea that secondhand smoke, though diluted, produces the same hazards as smoke inhaled directly from a cigarette.)
- Why do you think cigarette advertisement was banned from TV and the radio? (It was felt that advertisement was particularly dangerous for young people.)

EXTENSION

- Have the students ask their parents and other relatives whether they have ever been connected with the production, manufacture, transport, or sale of tobacco products.

DASH

Name________________________

Date________________________

STUDENT PAGE 5.6.7 THE TOBACCO QUIZ

1. **Tobacco first came from**
   a) Asia b) Europe
   c) Africa d) America

2. **Tobacco was first introduced as medicine.**
   True False

3. **In the United States tobacco is the most profitable major crop per acre.**
   True False

4. **The United States is the world's largest exporter of tobacco.**
   True False

5. **The United States is the world's largest producer of tobacco.**
   True False

6. **When was tobacco first recognized as a health hazard by the U.S. Government?**
   a)1832 b) 1864 c) 1932 d) 1964 e) 1984

7. **What diseases were first identified with use of tobacco?**
   a) heart disease d) bronchitis
   b) emphysema e) peptic ulcers
   c) lung cancer

8. **When was tobacco advertisement first banned from radio and TV?**
   a)1832 b) 1864 c) 1932 d) 1964 e) 1984

Name ____________________

9. **Tobacco is a major source of tax revenue in the United States.**
True False

10. **Tobacco is a major source of employment in the United States.**
True False

11. **What is the legal age for smoking in the different states?**
a) Varies b) 18 c) 21

12. **Tobacco use is addictive.**
True False

13. **Smoking by expectant mothers is a health hazard for unborn babies.**
True False

14. **When used by humans all forms of tobacco pose a health hazard.**
True False

15. **Smoking is not only dangerous to smokers but also to those who breathe secondhand smoke.**
True False

16. **Less than one-third of the adult U.S. population smoke regularly.**
True False

17. **There has been a steady decrease in the number of cigarettes smoked per person in the United States since 1982.**
True False

ACTIVITY 5.6.8 SMOKERS' SURVEY

OBJECTIVES

The students
- Develop a survey to find out why people started to smoke and why they have not quit.
- Carry out the survey and tabulate the data.
- Look at statistical implications of the survey.

BACKGROUND

This is one of a series of activities about tobacco, alcohol, and drugs. It should follow Activity 5.6.7 TOBACCO QUIZ and be used as a companion to Activity 5.6.9 EX-SMOKERS' SURVEY. In most communities and certainly at state and national levels smoking is increasingly being viewed as a major health hazard. Because it is not tied to much of the destructive psychological baggage of drugs and alcohol, it is easier to start discussion of addictive substances using tobacco as an example.

Survey

In SMOKERS' SURVEY the class constructs a survey to find out how smokers began smoking and why they continue. It not so subtly gets at the problem of quitting once one becomes addicted to tobacco. This is a common problem associated with all abused drugs. Activity 5.6.9 EX-SMOKERS' SURVEY is designed to be run along with SMOKERS' SURVEY. It may be advantageous to have half the class run one survey while the other half runs the other one. If the students are timid about asking questions, they can work in teams, preferably with two to a team.

Questioning

Guidelines for talking to people in the survey should be carefully developed before beginning the survey. They should cover interviewing family members or friends the students' parents agree could be interviewed without embarrassment. A note to the home describing the activity will help in the data collection.

Statistics and Population Size.

Because of the relatively small size of the group surveyed, there will be technical problems of overgeneralizing the results. Data collected may have regional, cultural, or other biases that will limit its universality. With smoking data this is usually not a problem because there are not now major regional variations in behavior. Cultural, regional, or other biases will not make the survey any less informative. Several questions at the end of EX-SMOKERS' SURVEY address sampling problems.

STUDENT ROLES

Survey planner
Survey taker

MATERIALS

Student Page 5.6.8 SMOKERS' SURVEY

PRODUCT

Completed survey

PROCEDURES

1. **Review the Smoking Quiz and the Tobacco Scrapbook. Ask the students to make hypotheses about why people started smoking and why they continue to smoke. Record the hypotheses.**

   Help the students include such things as
   - People got started because the health hazards weren't understood as well 20 or more years ago.
   - Smoking was a popular thing to do when they started.
   - Some people find smoking enjoyable.
   - People find quitting painful. Some may think they don't have enough reasons to stop.
   - Some people may be fearful about gaining weight if they stop smoking.

2. **Ask the students how we can find out why people started smoking and why they haven't quit.**

3. **Have the students work in small groups to plan a survey. Help them devise a set of interview questions for the whole class to use.**

Have the students include such questions as

- Why do you smoke?
- How do you feel when you smoke?
- How much do you smoke? How many cigarettes is this per day?
- How long have you smoked?
- How did you get started smoking?
- Have you ever tried to stop smoking? If so, why?
- Why did you start again? (If they stopped.)
- Do you think that smoking is affecting your health? How?
- Have you read or heard about hazards to your health caused by smoking?
- Do you believe that the information about those hazards is correct?
- Would you advise me to start smoking? Why?
- What age range are you in (child–19 years, 20–39 years, 40 years and beyond).

4. **Help the students develop a set of class guidelines for the survey.**

Include such things as

- The need for each student or group to interview at least two people for the survey.
- Using friends and family members where possible.
- Getting permission from parents before interviewing family friends.
- The way to talk when administering a survey.

5. **Help the students organize their data. Have them use Student Page 5.6.8 SMOKERS' SURVEY.**

Help them

- Calculate the cost of a single cigarette. (Work to the idea of dividing the cost of a pack by the number of cigarettes in it. They may want to get an average of the cost of the most common brands.)
- Calculate the number of cigarettes each person interviewed would smoke in a year.
- Calculate the yearly cost of cigarettes for each person they interviewed.

- Use the class data to calculate separately the average number of cigarettes smoked in a year by males and females according to their age range. (Have the students use three ranges (child–19 years, 20–39 years, 40 years and older).
- Use the class data to calculate separately the average cost of cigarettes smoked in a year by males and females according to their age range. (Have the students use the same age ranges as above.)
- Make bar graphs showing the average number of cigarettes smoked in a year by males and females according to their age range.
- Make bar graphs showing the average cost of cigarettes smoked in a year by males and females according to their age range.

6. **Help the students calculate the percentage of smokers in the three age ranges who agreed with the responses to selected health questions shown in Student Page 5.6.8, Item 9.**

7. **Have the students compare their hypotheses about why people started smoking and why they don't quit with the results of the survey.**

   Ask such questions as
   - Were your hypotheses correct?
   - What seems to be the main reason why people don't stop smoking once they start?
   - What were the most common reasons for starting to smoke?
   - Why it is usually better never to start smoking rather than to start then stop?

8. **Have the students write a brief essay on how these statistics help them decide whether to continue, stop, or start smoking.**

EXTENSIONS

Have the students
- Exchange survey findings with other DASH classes in their school.
- Use the Internet to share their survey findings with DASH 5 classes in other schools.

Name________________________

Date________________________

STUDENT PAGE 5.6.8 SMOKERS' SURVEY

1. Attach the list of questions you used in your survey.
2. Attach a record of the answers you got to your questions.
3. Calculate the cost of a cigarette. Cost per cigarette ______
4. Calculate the number of cigarettes smoked by the people you interviewed and their cost per day and year. Record your data in the table below.

Person interviewed	Number of cigarettes per day	Number of cigarettes per year	Cost per day	Cost per year
# 1				
# 2				
# 3				
# 4				
# 5				

Name ______________________

5. Use the class data to calculate the average number of cigarettes smoked in a year by the males and females according to their age range (child–19 years, 20–39 years, 40 years and older). Record your data on the table below.

Gender	Average Number of Cigarettes per Year		
	(child–19 yr)	*(20-39 yr)*	*(40 yr & older)*
Females			
Males			

6. Make a bar graph showing the average number of cigarettes smoked in a year by the males and females according to their age range (child–19 years, 20–39 years, 40 years and older).

7. Use the class data to calculate the average cost of the cigarettes smoked in a year by the females and males according to their age range. Record your data on the table below.

Gender	Average Cost of Cigarettes per Year		
	(child–19 yr)	*(20-39 yr)*	*(40 yr & older)*
Females			
Males			

Name ____________________

8. Make a bar graph showing the average cost per year of cigarettes smoked by the males and females in the three age ranges (child–19 years, 20–39 years, 40 years and older).

9. Calculate the percentage of smokers in each age range who agreed with the responses to health questions shown in the table below.

Responses to Health Questions	Percentage of Responses *(child-19 yr)*		
		(20–39 yr)	*(40 yr & older)*
• Know about the health hazards of smoking and believe them			
• Know about the health hazards of smoking and do not believe them			
• Want to stop smoking			
• Have tried to stop smoking			
• Feel that smoking is adversely affecting their health			
• Would recommend that you take up smoking			
• Would recommend that you not take up smoking			

Name ______________________

10. Comment on other statistics from your survey that you feel are important.

11. What do these statistics do to help you make decisions about smoking?

SP 5.6.8–5

Name ______________________

ACTIVITY 5.6.9 EX-SMOKERS' SURVEY

OBJECTIVES

The students
- Develop a survey to find out why people stopped smoking.
- Carry out the survey and tabulate the data.

BACKGROUND

This is one of a series of activities on tobacco, alcohol, and drugs. It should follow Activity 5.6.7 THE TOBACCO QUIZ and be used along with Activity 5.6.8 SMOKERS' SURVEY. Stopping smoking is increasingly being viewed as a major factor in improving our average national life expectancy. It is often easier to discuss smoking as an entry into the world of harmful substances than alcohol or drugs.

Survey

In EX-SMOKERS' SURVEY the students construct a class survey to find out why people quit smoking. It gets at the idea that even though it is difficult, many people do quit smoking. Activity 5.6.8 SMOKERS' SURVEY is designed as a companion activity. It may be advantageous to have half the class run one survey while the other half runs the remaining survey. If the students are timid about asking questions of others, they can work in teams.

Interview Guidelines

Guidelines for talking to people in the survey should be carefully developed. They should include interviewing family members or friends that the students' parents agree could be interviewed without embarrassment. A note to the parents describing the activity will help in the data collection.

Statistics

In formal statistical analysis, samples of less than 15 persons are normally suspect; however, this technical problem should only act as a reminder to avoid overgeneralizing the results. The data collected may have regional, cultural, or other biases that will limit their universality. Such biases will not make the survey any less informative.

STUDENT ROLES

Survey planner
Survey taker

MATERIALS

Student Page 5.6.9 EX-SMOKERS' SURVEY

PRODUCTS

Survey
Completed Student Pages

PROCEDURE

1. **Ask the students to consider why some people have stopped smoking and have not gone back to it. Ask them to suggest hypotheses as to why people would quit and why they would not start again. Have the students record their hypotheses.**

   Help them include such things as the following:
   - People may have stopped smoking because it was seen as a health problem.
   - People may not have felt well when they smoked or their doctor suggested or insisted that they quit.
   - People may have not started again because they felt much better after they quit.
   - People may believe they would be risking too many health problems to go back to smoking.

2. **Ask the students how we can find out why people quit smoking and did not return to it. Work to the idea of surveying smokers and ex-smokers at the same time. See Activity 5.6.8 SMOKERS' SURVEY.**

3. **Have the students work in small groups to devise a set of questions for the entire class to use for a survey.**

   Be sure they include such questions as
   - Why did you quit smoking?
   - How do you feel now that you have quit smoking?

- How much did you smoke? How many cigarettes per day?
- How long did you smoke?
- How did you get started smoking?
- Did you try quitting several times before you were successful?
- Did you think that smoking was affecting your health? How?
- Did you believe warnings about the hazards of smoking?
- Would you advise me to start smoking? Why?
- What age range are you in (child–19 years, 20–39 years, 40 years and older)?

4. **Help the students develop a set of class guidelines for the survey.**

Include such things as

- Interviewing family members.
- Getting parental permission to interview people if necessary.
- The way to talk when conducting a survey.

5. **Help the students organize their data. See Student Page 5.6.9 EX-SMOKERS' SURVEY.**

Help them

- Calculate the cost of a single cigarette. (Work to the idea of dividing the cost of a pack by the number of cigarettes in it. They may want to get an average of the cost of most common brands.)
- Calculate the number of cigarettes each person they interviewed smoked in a year.
- Calculate the yearly cost of cigarettes for each person they interviewed.
- Use the class data to calculate separately the average number of cigarettes smoked in a year by male and female ex-smokers according to their age range. (Have the students use three ranges: child–19 years, 20–39 years, 40 years and older.)
- Calculate separately the average cost of cigarettes smoked in a year by male and female ex-smokers. (Have the students use the same age ranges as above.)
- Make bar graphs showing the average number of cigarettes smoked in a year by male and female ex-smokers.
- Make bar graphs showing the average cost of cigarettes smoked in a year by male and female ex-smokers.

6. **Help the students calculate the percentage of ex-smokers who agreed with the responses to selected health questions shown in Student Page 5.6.9, Item 9.**

7. **Help the students compare their starting hypotheses with the results of the survey.**

   Ask such questions as
   - How were your hypotheses borne out?
   - What seems to be the main reason people stopped smoking?
   - What was the most common reason for starting to smoke?
   - In what way were the people who had stopped smoking different from the people who have not yet stopped smoking? (Compare results with results from Activity 5.6.8 SMOKERS' SURVEY.)

8. **Help the students look at the problem of generalizing from the data.**

   Ask such questions as these:
   - Do you think the data we have collected and our analyses apply fairly well to people in your community? (Get a sense of the students' feeling.)
   - How could we find out how well they apply? (Develop the idea of doing further testing.)
   - How might we do that? (Work to such ideas as joining data with other classes and getting a bigger sample.)
   - Do you think the data we have collected and our analyses apply fairly well to the whole country? (Get a sense of the students' feeling.)
   - How could we find out how well they apply? (Further develop the idea of doing additional testing, possibly adding different schools from across the country. This would be an interesting Internet project.)
   - Do the percentages of people who stopped and started smoking again tell us whether a particular smoker will be a "stop and restart smoker"? (Get at the idea that statistics do not tell us what individuals will do, they tell us only what part of a group of people are likely to do.)
   - How might we be sure we have an unbiased sample? (Develop the idea of a random sample as one in which people are selected without any pattern—haphazardly or by chance.)
   - What kinds of things might have biased the responses of our sample of ex-smokers? (Explore such ideas as the people

surveyed were people we know who probably wouldn't want to make a bad impression, so they might have given answers they felt would be acceptable.)

9. **Have the students write a brief essay on how these statistics help them in deciding about smoking.**

EXTENSIONS

Have the students

- Share their findings with other DASH classes in their school.
- Exchange data with other schools on a telecommunication network.

DASH

Name____________________________

Date____________________________

STUDENT PAGE 5.6.9 EX-SMOKERS' SURVEY

1. Attach the list of questions you used in your survey.
2. Attach a record of the answers you got to your questions.
3. Calculate the cost of a cigarette. Cost per cigarette ___
4. Calculate the number of cigarettes smoked by the ex-smokers you interviewed and their cost per day and year. Record your data in the table below.

Ex-smoker interviewed	Number of cigarettes per day	Number of cigarettes per year	Cost per day	Cost per year
# 1				
# 2				
# 3				
# 4				
# 5				

Name_______________________________

5. Use the class data to calculate the average number of cigarettes smoked in a year by male and female ex-smokers according to their age range (child–19 years, 20–39 years, 40 years and older). Record your data on the table below.

Gender	Average Number of Cigarettes per Age Group		
	(child–19 yr)	*(20–39 yr)*	*(40 yr & older)*
Females			
Males			

6. Make a bar graph showing the average number of cigarettes smoked in a year by male and female ex-smokers according to their age range (child–19 years, 20–39 years, 40 years and older).

7. Use the class data to calculate the average cost of the cigarettes smoked in a year by female and male ex-smokers according to their age range. Record your data on the table below.

Gender	Average Cost of Cigarettes per Age Range		
	(child–19 yr)	*(20-39 yr)*	*(40 yr & older)*
Females			
Males			

Name______________________________

8. Make a bar graph showing the average cost per year of cigarettes smoked by male and female ex-smokers in the three age ranges (child–19 years, 20–39 years, 40 years and older).

9. Calculate the percentage of ex-smokers in each age range who agreed with the responses to the health questions shown in the table below.

Responses to Health Questions	Percentage per Age Range		
	(child–19 yr)	*(20–39 yr)*	*(40 yr & older)*
• Knew about the health hazards of smoking and believed them			
• Know about the health hazards of smoking and do not believe them			
• Wanted to stop smoking			
• Tried to stop smoking several times before succeeding			
• Felt that smoking was adversely affecting their health			
• Would recommend that you take up smoking			
• Would recommend that you not take up smoking			

10. Comment on other statistics from your survey that you feel are important.

Name______________________________

11. What do these statistics do to help you make decisions about smoking?

SP 5.6.9–5

Name ________________________

10.18"

ACTIVITY 5.6.10 SMOKING LAWS

OBJECTIVES

The students
- Research the groups that make the laws and rules we live by.
- Research the laws about smoking at the federal, state, community, and school levels.
- Consider the problems in enforcement of smoking laws.
- Practice decision making.

BACKGROUND

This is one of a series of activities on tobacco, alcohol, and drugs. It should follow Activity 5.6.8 SMOKERS' SURVEY and 5.6.9 EX-SMOKERS' SURVEY.

Since the spring of 1997 when the federal courts categorized tobacco as a drug, the U.S. government has increased its control over tobacco sales, particularly to minors. News articles in the Tobacco Scrapbook will give a fascinating account of the attitudinal change of various legislative bodies.

The Message

The fundamental message to students is that though the government may eventually produce health-protecting court decisions and legislation, the governmental process may take years. In the meantime, where possible, one must take charge of one's own life in matters of danger to personal health and safety. This involves
- Learning about health and safety.
- Being careful and sure about facts.
- Acting in a way that effectively uses knowledge.
- Allying oneself with others who act on the basis of considered facts.

In this activity the students research the laws and rules of the federal government, state, local community, workplace, and school concerning smoking. They also compare what is happening in their state and other parts of the country. This activity provides a good opportunity for the students to share information over the Internet.

Making Decisions
To help the students in their decision making offer the following simple guide. Suggest that they ask themselves

- What is the problem or situation that requires a decision?
- What are reasonable ways to respond to the problem or situation?
- What are the consequences of each response?

Then suggest that they select the response likely to produce the most favorable consequences and act accordingly.

To help the students ensure that decisions are carried out suggest that

- When a similar problem or situation arises, they review why they made the original decision.
- They ally themselves with others who have made the same decision.

STUDENT ROLES

Researcher
Philosopher

MATERIALS

U.S. maps
maps of your state showing counties and cities
maps of your political area showing school districts
Student Page 5.6.10 SMOKING LAWS

PRODUCTS

Completed Student Pages

PROCEDURES

1. **Introduce the question of who makes the laws and rules that govern our daily lives.**

   Ask such questions as
   - How many different groups of people make laws and rules that govern our lives? (Entertain all answers.)
   - What group makes laws for all of the nation? (Probe for the U.S. Congress. Its members are the lawmakers of our national government.)

- How large an area is the U.S. Congress responsible for? (Introduce a map of the 50 states. You may want to add Puerto Rico, the Virgin Islands, Guam, and the islands of Micronesia.)
- Are there other national-level groups that make rules? (Use a "big city" phone book to find such groups as the federal Alcohol, Tobacco, and Firearms Bureau, the Food and Drug Administration, the Environmental Protection Agency, and so forth. Agencies, bureaus, departments, commissions, boards, and services all make rules at the direction of Congress.)
- How is the United States divided into smaller governmental regions? (Work for the idea that the nation is divided into states.)
- What group makes laws for our state? (Probe for the state legislature.)
- What are other state rule-making groups? (Again use the phone book. The same general titles [agencies, administrations, and so forth] used within the federal government are also used for state groups.)
- Are there governmental subdivisions within the states? (Work to the idea of counties, parishes, cities, towns, school districts, and so forth. Show a map of the counties and other political subdivisions in your state.)
- Are there groups within these subdivisions that make laws and rules? (Include such governmental groups as county and city councils or commissions, school boards, and so forth.)
- Do other groups make rules? (Include such groups as teachers, employers, churches, parents, and so forth.)

2. **Help the students use Student Page 5.6.10 SMOKING LAWS to develop a class chart ranking the law- and rule-making groups in Procedure 1 in order of the number of people they serve. Have the students start with the U.S. Congress.**

3. **Introduce the problem of finding out who has made the laws and rules governing smoking in the past and who is making them now.**

   Ask such questions as

   - Do you know of any laws or rules that any of the groups listed in Procedure 2 have made concerning smoking? (First list the rules the students refer to and next the law or rule-making group involved.)

- How can we find out who has made other rules about smoking and what they are?

4. **Have the students work in small groups to decide how they will find out what rules and laws have been made about smoking. Have them carry out their research.**

   Help them include such techniques as
   - Asking parents and other adults.
   - Writing, phoning, or going to the information section of the city, state, or federal government.
   - Going to the library.

5. **Have the students complete Student Page 5.6.10 SMOKING LAWS to make a chart showing the smoking rules that have been made by any of the groups they have listed.**

   Ask such questions as
   - What are the rules and laws concerning smoking by young people? Who makes these laws and rules?
   - What kinds of smoking laws exist in your state to protect people in the workplace? Why have these laws been made?
   - What are the rules in our school concerning smoking?
   - What types of penalties are there for breaking the various laws or rules?
   - Who enforces the rules or laws?

6. **Ask the students what they can do when they see someone breaking a smoking law or rule. Have them discuss this in small groups and then present their suggestions.**

   Be sure they consider that
   - They are children in the eyes of adults.
   - A question asked about a person's knowledge about a rule or law is less confrontational than statements about right and wrong.
   - Stage-whispered questions to someone else often alert people who are unaware that they are violating laws or rules.
   - Peers, too, are often best addressed through questions.
   - If someone is not moved to stop smoking, the final appeal is to someone with enforcement power (airline attendants, building guards, teachers, and so forth), but this should be done with care.

7. **Have the students respond to the statement: To enjoy good health and safety we must learn the facts that are available about health and safety.**

   Get at the ideas that
   - To do or not do something such as smoking involves a decision.
   - A person who has no knowledge about smoking has no reason to smoke or not to smoke. Such a person cannot make an informed decision.
   - People with knowledge about smoking have reasons for making their decision.

8. **Have the students respond to the statement: To make good health decisions we should be sure of the reliability of our information.**

   Pursue the observation that our information may be wrong, particularly if we are relying only on what friends say. This means that we need to check
   - Where statements come from.
   - When statements were made. (Information is often corrected over time.)
   - The authority of the statements.
   - We need to be constantly alert to new information. (The ideas of scientists and health workers can change as more research is done.)

9. **Have the students respond to the statement: We need to use information effectively.**

   Help them include the following ideas in their discussion:
   - We may know what is good for us but not always make decisions that reflect our knowledge.
   - Making decisions based on knowledge takes practice.
   - It takes time to reflect on the best things to do. (Have the students think back on how they spend time weighing different ideas when deciding how to do something, for example, in their yearly goal setting.)

10. **Have the students respond to the statement: We can make considered decisions by selecting actions that are likely to produce the most favorable consequences.**

    Work with the idea that
    - Once a problem has been recognized, solutions and consequences can be identified, and the action likely to produce the most favorable consequences can be selected.

11. **Have the students respond to the statement: We need to get to know other people who act on the basis of knowledge and reason.**

    Work with the notion that
    - By talking with others who are making decisions based on reason and knowledge, we gain additional sources of research and a way of getting validation or counterevidence for our understanding and decisions.

12. **Have the students respond to the statement: We need to remember why we have made a decision to do or not do something.**

    Call the students' attention to the need to remind ourselves why we do what we do, for example, why we have to get up in the morning, feed the cat, eat properly, and stay away from tobacco, drugs, and alcohol.

EXTENSION

- Have the students compose aphorisms about staying away from tobacco. Help them see that an aphorism is a kind of rule.

DASH

Name________________________

Date_________________________

STUDENT PAGE 5.6.10 SMOKING LAWS

1. List government and other law-making groups in order of the number of people they serve. Start with the United States Congress.

2. What laws, if any, have each of these law-making groups made about smoking?

3. List the things you can do when someone breaks a smoking law.

SP 5.6.10–2

Name ______________________

4. What is meant by the statement that to enjoy good health and safety we must learn the facts that are available about health and safety?

5. What is meant by the statement that to make good health decisions we should be sure of the reliability of our information?

6. What is meant by the statement that we need to use information about health and safety effectively?

Name ______________________

7. What is meant by the statement that we can make considered decisions about health and safety by selecting actions that are most likely to produce the most favorable consequences?

____

____

____

____

____

8. What is meant by the statement that we need to get to know other people who act on matters of health and safety on the basis of knowledge and reason?

____

____

____

____

____

9. What is meant by the statement that we need to remember why we have made a decision to do or not do something?

____

____

____

____

____

ACTIVITY 5.6.11 ALCOHOL QUIZ

OBJECTIVES

The students

- Take an information-giving quiz on the history of alcohol use.

BACKGROUND

This is one of a series of activities on tobacco, alcohol, and drugs. As noted earlier, it is often confusing to students to find that tobacco and alcohol are drugs that pose a definite health hazard but are not considered illegal for sale to adults. The information-giving Alcohol Quiz helps put the history of alcohol into perspective.

STUDENT ROLE

Historian

MATERIALS

Student Page 5.6.11 ALCOHOL QUIZ

PRODUCTS

Completed Student Pages

PROCEDURES

1. **Introduce the activity by challenging the students to answer the questions found in Student Page 5.6.11 ALCOHOL QUIZ. Encourage them to guess if they don't know the answers. Read the questions to them so that there is no air of testing.**

ALCOHOL QUIZ

1. **Alcohol is a natural product of yeast acting on fruit juices or other sugar solutions.**
   True False

   True. Fruit juices can sometimes turn into an alcoholic beverage when left standing in open containers.

2. **Alcohol is a drug that affects the nervous system, and it has been used as an anesthetic for centuries.**
   True False

   True. The primary effect of alcohol on the nervous system is sedation or calming. Prior to the 19th century alcohol was the primary anesthetic doctors had available to them.

3. **To the yeast that produce it, alcohol**
   a) Is a waste b) Is a poison c) Is lethal d) All of the preceding

   d) All of the preceding. Alcohol is a toxin to the yeast as it is to humans. When the alcohol content of a sugar solution goes above 12 to 14 percent, the yeast is killed. For this reason beverages with more than 14 percent alcohol must be distilled. Stills were invented about 500 years ago. In distilling, water is removed from the beverage.

4. **People who become drunk lose control over their nervous system.**
   True False

   True. They may lose control of their muscles, speech, and thought processes as well as their sense of pain, vision, and hearing.

5. **Sale of alcoholic drinks has always been legal in the United States.**
   True False

   False. The United States had a prohibition on the sale of alcoholic beverages from 1920 until 1933. This was called the Prohibition Era.

6. **The more body mass people have, the more alcohol they can handle before showing signs of drunkenness.**
   True False

   True. The amount of alcohol people can safely consume is determined by body mass. A 160-pound (72-kg) person can usually handle more than twice the amount of alcohol before appearing drunk that an 80-pound (36-kg) person can.

7. **A person who is a regular long-time drinker takes longer to get "high" than a person who has just started drinking.**
True False

True. As with all drugs, the body gains a greater tolerance for the drug the more it is used.

8. **A person may get "high" on a single can of beer or glass of wine.**
True False

True. One can of beer or glass of wine is enough to affect the centers of judgment of a 70-to-80-pound person. Two to four drinks will begin to affect motor control of such a person.

9. **Extended use of alcohol may produce**

a) Liver damage
b) Brain damage
c) Kidney damage
d) Heart damage
e) Cancer
f) All of the preceding

f) All of the preceding. The long-term use of alcohol may damage many different organs. Some of this damage can be arrested by stopping drinking.

10. **Alcohol is involved in a large proportion of fatal automobile accidents.**
True False

True. Some 50 percent or more of automobile accidents in the United States involve persons who are legally drunk.

11. **What is the legal age for drinking in your state?**
a) Any age b) 18 c) 21

c) The legal age is 21 in most states.

12. **Alcohol use can be addictive.**
True False

True. Many people become dependent on alcohol, thus are addicted.

13. **The drinking of alcoholic beverages by expectant mothers is a health risk for the unborn babies.**
True False

True. The U.S. Surgeon General warns that drinking alcoholic beverages increases the danger of infant mortality and low birth weight.

14. **About 10 percent of the adult population is alcohol-dependent.**
True False

True. About 10 percent of the adult population is alcohol-dependent. Though the amount of alcohol consumed in the United States has decreased, the percentage of persons dependent on alcohol has remained fairly constant over the last 20 years.

15. **Breaking addiction to alcohol usually requires professional help.**
True False

True. Breaking the bonds of addiction almost always requires help because many broken parts of a life must be put back together.

16. **Alcohol is a common solvent in medicines.**
True False

True. Alcohol is found in many liquid medicines and medicine-like preparations such as mouthwashes.

17. **The percentage of smokers that become addicted to tobacco is greater than the percentage of drinkers that become addicted to alcohol.**
True False

True. Most regular smokers become tobacco-dependent and suffer withdrawal symptoms when attempting to stop smoking. Only 10 percent of alcohol drinkers become dependent.

18. **Child and spouse abuse, crime, automobile wrecks, and loss of jobs are often associated with alcohol use but not with the use of tobacco.**
True False

True. Relatively little social damage or damage to others is inflicted by smokers, the exceptions being damage to a fetus and to those inhaling secondhand smoke. People under the influence of alcohol often act in all the antisocial ways listed.

3. **Have the students look at the labels of different medicines and food additives and note their alcohol content. List the substances that contain alcohol.**

Ask such questions as these:

- Why do you think so many medicines and food additives contain alcohol? (Get at the idea that alcohol is a very important solvent and sometimes the best one to hold medicine and other things in a liquid state.)

- Why are these medicines and other alcohol-containing liquids not considered to be alcoholic beverages? (Work to the idea that they are not being used for their intoxicating properties.)
- Can a drug such as alcohol have both a health- and nonhealth-promoting side? (Obviously in the case of alcohol it presents a health hazard when it is used as an intoxicant. However, when used for its solvent properties, it may be a necessary component of a medicine.)

EXTENSION

- Have the students relate the information in their Alcohol Scrapbook to the Alcohol Quiz.

DASH

Name____________________________

Date____________________________

STUDENT PAGE 5.6.11 ALCOHOL QUIZ

ALCOHOL QUIZ

1. **Alcohol is a natural product of yeast acting on fruit juices or other sugar solutions.**
   True False

2. **Alcohol is a drug that affects the nervous system, and it has been used as an anesthetic for centuries.**
   True False

3. **To the yeast that produce it, alcohol**
   a) Is a waste b) Is a poison c) Is lethal d) All of the preceding

4. **People who become drunk lose control over their nervous system.**
   True False

5. **Sale of alcoholic drinks has always been legal in the United States.**
   True False

6. **The more body mass people have, the more alcohol they can handle before showing signs of drunkenness.**
   True False

7. **A person who is a regular long-time drinker takes longer to get "high" than a person who has just started drinking.**
   True False

8. **A person may get "high" on a single can of beer or glass of wine.**
   True False

Name ______________________________

9. **Extended use of alcohol may produce**

   a) Liver damage
   b) Brain damage
   c) Kidney damage
   d) Heart damage
   e) Cancer
   f) All of the preceding

10. **Alcohol is involved in a large proportion of fatal automobile accidents.**

    True False

11. **What is the legal age for drinking in your state?**

    a) Any age b) 18 c) 21

12. **Alcohol use can be addictive.**

    True False

13. **The drinking of alcoholic beverages by expectant mothers is a health risk for the unborn babies.**

    True False

14. **About 10 percent of the adult population is alcohol-dependent.**

    True False

15. **Breaking addiction to alcohol usually requires professional help.**

    True False

16. **Alcohol is a common solvent in medicines.**

    True False

17. **The percentage of smokers that become addicted to tobacco is greater than the percentage of drinkers that become addicted to alcohol.**

    True False

18. **Child and spouse abuse, crime, automobile wrecks, and loss of jobs are often associated with alcohol use but not with the use of tobacco.**

    True False

ACTIVITY 5.6.12 ALCOHOL LAWS

OBJECTIVES

The students
- Research laws concerning alcohol at the federal, state, community, and school levels.
- Relate these laws to their information on health hazards.

BACKGROUND

This is one of a series of activities on tobacco, alcohol, and drugs. It should follow Activity 5.6.11 ALCOHOL QUIZ. In ALCOHOL LAWS the students collect information about laws governing the use of alcohol.

History

After World War I the United States took a constitutional stand against the sale and consumption of alcohol. The 18th amendment on prohibition of liquor was ratified in 1919 and became effective in 1920. It was repealed in 1933. Commentators reflecting on the period point out that prohibition was imposed on a large segment of our population that did not fully agree with the idea of alcoholic abstinence and continued to buy bootlegged alcohol. This created a powerful, well-organized underworld that learned how to function in the political fringes of society and continues to function today.

Despite the known health hazards and human tragedy resulting from abuse of alcohol, our society has not been willing to impose another prohibition. We have opted to legislate at the edges of the problem, creating laws to prohibit drunk driving, drinking in certain public parks and some other public premises, and the use of alcohol by minors.

Teacher's Role

Society is heavily relying on our capacity as teachers to educate students about the dangers of substance abuse and help them develop a personal philosophy to cope with today's problems. In keeping with this philosophy, DASH emphasizes the collection of information through guided research and deals with the affective aspects through the use of "choice" books and other readings. Activity 5.6.13 CHRIS'S STORY and 5.6.14 THE PARENTS' STORY are based on DASH choice books.

The Message

Again the fundamental message to students is that, where possible, one must take charge of one's own life in matters of danger to personal health and safety. This includes

- Learning about health and safety.
- Being careful and sure about the information we find.
- Acting in a way that effectively uses knowledge.
- Aligning oneself with others who act on the basis of considered facts.

In ALCOHOL LAWS the students research the laws of the federal government, state, community, workplace, and school concerning alcohol. Finally, they discuss the nature of laws and rules in society. This provides an opportunity to compare the wider society's laws and rules with the rules of the home and school. Again, the message is that the success of a democracy depends on citizens' agreement to accept law and submission to law. Changing of law is always a political option to be carried out through acts of elected representatives.

Some points to be made are that

- The success of a rule or law is determined more by how much people believe in the rule or law than in the way that it is enforced.
- Laws and rules are successful only when we agree to them and support them.
- Laws and rules are essential to making our complex society work.
- In a democracy, laws are made to benefit the citizens.
- We can better support laws when we understand why they have been made.
- Makers of laws and rules about alcohol and tobacco consider them necessary to make our society healthy and safe.

STUDENT ROLE

Researcher

MATERIALS

Student Page 5.6.12 ALCOHOL LAWS

PRODUCTS

Completed Student Pages

PROCEDURES

1. **Point out that we have looked at the laws and rules society has placed on the use of tobacco, and we now will look at those placed on the use of alcohol. Have the students use the chart of government developed in Activity 5.6.10 SMOKING LAWS.**

   Ask such questions as
   - Does anyone know of any laws concerning the consumption of alcoholic beverages?
   - At what level of government was this law or rule made?
   - How is this rule enforced?
   - What is the reason behind the law or rule?

2. **Have the students work in small groups to decide how they will find out what rules and laws concerning alcohol are operating in the community. Help them carry out the research.**

   Help the students include such techniques as
   - Asking parents and other adults.
   - Writing, phoning, or going to the information section of the city or state government. (See phone books.)
   - Going to a federal building and asking.
   - Going to the library.

3. **Help the students make a chart showing the alcohol rules and laws that have been decided by various groups.**

   Ask such questions as these:
   - What are the rules and laws concerning alcohol and youths? Who made those laws and rules?
   - What kind of laws exist in your state regarding alcohol and the workplace? Why have these laws been made?
   - What laws have been made about operators of vehicles involved in public transportation? (Planes, trains, buses, and so forth.)
   - What are the rules in your school concerning alcohol?
   - What penalties are there for breaking the various laws or rules?
   - Who enforces the rules or laws?
   - How are the rules and laws concerning alcohol similar to those concerning tobacco?

4. **Have the students respond to the statement: The success of a rule or law is determined more by how much people believe in it than in the way that it is enforced.**

   Get at such ideas as
   - There are many opportunities to break rules and laws when there is no one around to enforce them—a classroom without a teacher, a home without parents, and so forth.
   - For a law or rule to work it must operate even when no one is around to enforce it.
   - Laws and rules are successful only when we agree to them and support them. (Note that in the classroom, at home, and on the playground the stated laws of legal behavior or the rules of courtesy don't work if no one follows them. We individually and collectively make rules and laws work by following them, whether or not someone else is there to enforce them. We become self-regulating citizens.)

5. **Have the students respond to the statement: Laws and rules are essential to making our complex society work.**

   Get at such ideas as
   - Traffic could never move if we could drive on both sides of the highway; there would be no public services, highways, or parks; and we would be reduced to tribal organization or brutal authority.
   - In our society laws are made to benefit the citizenry. (Have the students think about the stated and unstated rules that exist in the classroom and home to make things work better.)

6. **Have the students respond to the statement: By finding out why rules and laws were made we can better support them.**

   - Ask for examples. (One example might be a class rule about washing hands before lunch. When we know that we are washing away germs, we are more likely to be thorough in the way we wash our hands. Knowing why we do something helps remind us to do it.)

7. **Have the students respond to the statement: Rules and laws about alcohol and tobacco are needed to make our society healthy and safe.**

8. **Have the students review what they have learned about health hazards from the scrapbooks, quizzes, and other sources.**

EXTENSION

- Have the students compose aphorisms about alcohol and its use.

DASH

Name________________________

Date________________________

STUDENT PAGE 5.6.12 ALCOHOL LAWS

1. List laws about alcohol that came from the federal government.

2. List laws about alcohol that came from your state government.

3. List laws about alcohol that came from your city government.

4. List rules about alcohol that came from your school board.

SP 5.6.12-2

Name ____________________

5. What is meant by the statement that the success of a rule or law is often determined more by how much people believe in it than the way that it is enforced?

6. What is meant by the statement that laws and rules are essential to making our society work?

7. What is meant by the statement that by finding out why rules and laws were made we can better support them?

8. What is meant by the statement that rules and laws about alcohol and tobacco are needed to make our society healthy and safe?

ACTIVITY 5.6.13 CHRIS'S STORY

OBJECTIVES

The students
- Read *Chris's Story.*
- Comment on the story.

BACKGROUND

This is one of the activities in a series about tobacco, alcohol, and drugs. It should follow Activity 5.6.12 ALCOHOL LAWS. *Chris's Story* is the first in a set of two books about the temptations of a group of preteens and teenagers in a party situation and the trials of their parents in response to their actions.

Affective Content

To this point in the tobacco, alcohol, and drug series of activities the emphasis has been on factual information. In *Chris's Story* the emphasis is on the affective aspects of today's problems. In this book, the students follow two young girls as they go to a party where alcohol, tobacco, and drugs are freely used and where involvement in sex hovers. In the second book, *Paula and Bob's Story,* the students follow the response of the girls' parents as they are drawn into the escapades of their daughters. These books are designed to give the reader some control over the plot according to the choices they make for the characters.

Caution

Review the book carefully before using it. The content may not be within the experience of your students. You may determine that the book is more appropriate for inclusion at a later grade level. You may want to engage peers, administrators, or others in your deliberations. This particular book is *not* essential to the drug-and-alcohol sequence. However, the limitations of descriptive science in carrying the full message of mental health are recognized in this book.

Class Use

The power of the story is enhanced by post-reading discussion. A discussion led by students will often develop the greatest in-depth probing of the content of the book. Such discussion can be done in large or small groups. It should involve the problems in each decision point. To get as wide a range of comments as possible and to protect the commenting students, observations should be made in the name of the characters; for example, "Chris could have thought . . .," "Chris probably felt . . .,"rather than "If I were Chris . . ." or "I would have thought . . . ." You may wish to have several discussions or leave all discussion until the book is finished.

STUDENT ROLE

Protagonist in a novel

MATERIALS

Chris's Story
Student Page 5.6.13 CHRIS'S STORY

PRODUCTS

Completed Student Pages

PROCEDURES

1. **Have the students read *Chris's Story* and keep track of the decisions that are made.**

2. **Have the students lead a discussion. Identify the leaders and set down the ground rules for review.**

   Include such things as
   - The need to speak in the name of the characters of the story rather than in one's own name, for example, "Chris might have felt . . . ."
   - Explore possible alternative actions and consequence of each action that should have been considered before decisions in the story were made.
   - Explore why Chris and others may have made the decisions they made.

3. **Have the students list the things Chris should have learned in going to the party. Have them use SP 5.6.13 CHRIS'S STORY.**

EXTENSION

- Have the students discuss what they think the parents said to Chris and Lisa.

DASH

Name________________________

Date_________________________

STUDENT PAGE 5.6.13 CHRIS'S STORY

List the things Chris should have learned from going to the party.

ACTIVITY 5.6.14 THE PARENTS' STORY

OBJECTIVES

The students
- Read *Paula and Bob's Story.*
- Explore the perspective of parents of a teenager who has broken a family confidence.
- Develop a reconciliation scenario.

BACKGROUND

This activity is part of the sequence about tobacco, alcohol, and drugs. It should follow Activity 5.6.13 CHRIS'S STORY, which is based on the first of a set of books about the temptations of a group of preteens and teenagers at a party. THE PARENTS' STORY, which is based on *Bob and Paula's Story,* the second book of the set, explores the other side of the story as the parents respond to their children's actions.

Affective Content

In the first book of the series the students follow two young girls as they go to a party where alcohol, tobacco, and drugs are being freely experimented with and where involvement in sex threatens. In the second book the students follow the response of the girls' parents as they are drawn into the escapades of their daughters.

Class Use

Post-reading discussion led by the students will often develop the greatest in-depth probing of the content of the book. The discussion can be done in large or small groups. It should involve the problem in each decision. To get as wide a range of comments as possible and to protect the students, observations should be made in the name of the characters. Encourage the students to use such phrases as "Chris's mom could have thought" and "Chris's dad probably felt" rather than "If I were Chris's dad" or "I would have thought." You may wish to have several discussions as the reading progresses or leave all discussion until the students have completed the book.

STUDENT ROLE

Social commentator

MATERIALS

Paula and Bob's Story
Student Page 5.6.14 THE PARENTS' STORY

PRODUCTS

Completed Student Pages

PROCEDURES

1. **Have the students read *Paula and Bob's Story.* Have them keep track of the decisions that are made.**

2. **If students are to lead the discussion, identify the leaders and set down the ground rules for review.**

   Include such things as
   - The need to speak in the name of the character of the story rather than in one's own name; for example, "Chris's mom might have felt that. . . ."
   - Explore possible reasons for each decision.

3. **Explore what else could have happened to the parents.**

4. **Assume that Chris went to the party. Have the students write a scenario in which a positive relationship is built between Chris and her family in the days after the party. Have them use Student Page 5.6.14 THE PARENTS' STORY.**

EXTENSIONS

- Have the students write a positive story of what happens to Lisa after the incident.

DASH

Name____________________________

Date_____________________________

STUDENT PAGE 5.6.14 THE PARENTS' STORY

Write a scenario about the building of a positive relationship between Chris and her family in the days after the party.

`ACTIVITY 5.6.15 INTOXICATION

OBJECTIVES

The students
- Study the relationship between body weight and blood alcohol concentration.
- Calculate what their blood alcohol concentration would be after consuming different numbers of drinks.
- Study physical and psychological behaviors related to various blood alcohol concentrations.

BACKGROUND

This activity is part of the sequence on alcohol, tobacco, and drugs. It should be done after Activity 5.5.2 NUTRIENTS AND CELLS in which digestion and removal of toxins such as alcohol are simulated. INTOXICATION deals with the way the body and mind are affected by various amounts of alcohol. The students investigate the entry path of alcohol in the body, the way the alcoholic beverage industry standardizes drinks, the concentration of alcohol in a "drink," and the amount of alcohol needed to reach different levels of intoxication.

Path of Alcohol in the Body

After reading a background discussion on alcohol the students trace how it enters and is distributed throughout the body. Use Student Page 5.5.2 NUTRIENTS AND CELLS and a model or anatomical drawing to review the organs involved in transporting and removing alcohol from the system.

Alcoholic Drinks

It is important that students who are about to enter the age of social experimentation have a sense of the alcohol content of commercial drinks. The alcohol content of a standard commercial "drink" is 17.5 mL. This is also the amount of alcohol that the average adult liver can process in an hour. For impact, have a student pour 17.5 mL of liquid into a container.

Simulation of Standard Commercial Drinks

Have on hand a liter of dark-colored water to represent alcohol. Also have available containers used for commercial drinks—5-oz wine glasses, 3-oz cocktail glasses, 1.5-oz shot glasses, and 12-oz beverage cans and bottles.

Demonstrate that a 12-oz can of water contains the same amount of liquid as a 12-oz bottle. For the remainder of the activity have the students use the bottle as the standard 12-oz container so that the contents can be seen.

In finding the volume of liquid needed to dilute the 17.5 mL of alcohol in various standard drinks, the students will probably do something like this:

- Pour 17.5 mL (0.6-oz) of colored water representing the alcohol in a standard drink into a container.
- Measure the volume of additional clear water needed to fill each container to its normal level. This will show how much each type of drink is diluted. Measurements will be approximate because drink containers are usually not calibrated. The degree of "fullness" will vary.
- Verify their measurements by calculating the amount of clear water that was added. For example, a commercial 12-oz beer can holds 348 mL of liquid of which 17.5 mL are alcohol. This means that 330.5 mL or 11.4 oz must be diluting water:

  348 mL – 17.5 mL = 330.5 mL or 12.0 oz – 0.6 oz = 11.4 oz.

Volumes of Standard Drinks

The table below shows the total volumes of various standard drinks, the volume of alcohol per drink, and the volume of diluting liquid (water, soda, juice, and so forth) in each drink.

Table 5.6.15 Volumes of liquids in various standard alcoholic drinks

Container	Contents	Total volume of drink	Volume of alcohol	Volume of diluting liquid
Shot glass	whiskey, gin, or vodka (40% alcohol)	43.5 mL (1.5 oz)	17.5 mL (0.6 oz)	26.0 mL (0.9 oz)
Cocktail glass	mixed drink (20% alcohol)	87.0 mL (3.0 oz)	17.5 mL (0.6 oz)	69.5 mL (2.4 oz)
Wine glass	wine (12% alcohol)	145.0 mL (5.0 oz)	17.5 mL (0.6 oz)	127.5 mL (4.4 oz)
Beer can or bottle	beer (5% alcohol)	348.0 mL (12.0 oz)	17.5 mL (0.6 oz)	330.5 mL (11.4 oz)

Intoxication and Amount of Alcohol

The students next interpret Table SP 5.6.15A-2, which shows the blood alcohol concentration (BAC) produced by different numbers of drinks. BACs are reported in percentages of alcohol in samples of blood. A person with a BAC of 0.10%, the legal limit in many states, has 0.10 mL of alcohol in every 100 mL of blood. Alcohol becomes part of the blood and other fluids in the body. The degree of intoxication is directly associated with the BAC of the person drinking.

BAC is affected not only by how much alcohol a person drinks but also by body weight and period of time over which the alcohol is drunk. If two people of different weights drink the same amount of alcohol in the same period, the heavier person will have the lower BAC. If two people of the same weight drink the same amount of alcohol in different periods of time, the one drinking slowly will have the lower BAC.

Estimating BACs

The students are then asked to estimate the least number of drinks that would produce different BACs for someone of their weight. To do this they use the information in Table SP 5.6.15A-2.

The data in the table can be expanded by having the students make their own calculations. Point out that the percentage in each cell of the table is a multiple of the BAC shown in the first cell and the number of drinks taken. For example:

- The BAC for a 150-pound person taking eight drinks can be found by multiplying 0.023% (the BAC in the first cell) x 8, which would give 0.184%. In the table 0.184% was rounded to 0.18%.
- The same person taking ten drinks would have a BAC of 0.23%. This would be found by multiplying 0.023% x 10, which would give us 0.23%.

Relating BACs to Behavior

Finally, the students are asked to relate BACs to mental and physical behavior. They use the estimated number of drinks required to reach selected BACs and then relate these BACs to the descriptions of behavior found in Table SP 5.6.15A-3.

STUDENT ROLE

Researcher

MATERIALS

model or anatomical drawing of the body
1 liter of colored water (Use food coloring to get a deep red or blue.)

three or four:
- 3-oz cocktail glasses
- 1.5-oz shot glasses
- 5-oz wine glasses
- 12-oz beverage bottles
- 12-oz beverage cans

graduates (student-made)
Student Pages 5.5.2 NUTRIENTS AND CELLS
5.6.15A INTOXICATION QUESTIONS
5.6.15B INTOXICATION

PRODUCTS

Completed Student Pages

PROCEDURES

1. **Introduce the question of what happens to people when they drink alcohol. Have the students read the background material in SP 5.6.15A INTOXICATION QUESTIONS.**

   Ask such questions as
   - Where does alcohol go in the body? (Use a model or drawing of human internal anatomy and have the students trace the alcohol to different parts of the body. Follow the alcohol from the small intestines to the heart and from the heart through arteries to the brain, liver, kidneys, and so forth.)
   - Where is alcohol broken down? (Help the students locate the liver.)
   - What is produced when alcohol is broken down? (Help the students recall that alcohol is broken down into carbon dioxide and water.)
   - How is water removed from our body? (Help the students recall that it mostly leaves in our urine and our breath but also in sweat, tears, feces, and other fluids.)
   - How is carbon dioxide removed from the body? (Help the students recall that it is removed in our breath. Remind the students of

work done in the DASH 4 Activity 4.6.7 SMOKING AND THE LUNGS in which exhaled gas was tested and found to contain carbon dioxide.)

- How much alcohol can the adult body remove in an hour? (Help the students recall from their reading that on average 17.5 mL are removed each hour.)

2. **Ask a volunteer to measure out the volume of simulated alcohol an adult can process in an hour.**

Ask such questions as

- Does that look like very much liquid? (Have the volunteer show 17.5 mL of colored water.)
- How much alcohol is in a standard commercial drink? (Work for agreement that the volume of alcohol is 0.6 oz or 17.5 mL.)
- Is this more or less than the amount that the average adult liver can process in an hour? (Work for agreement that it is about the same.)

3. **Have the students work in small groups to measure 17.5 mL (0.6 oz) of colored water. Assign different kinds of drinks from Table SP 5.6.15A-1 to the groups and have them show the relative amount of alcohol dilution in the various drinks.**

Have the students devise their own techniques for measuring the alcohol and the diluting water in the drink. Help them calculate the amount of diluting water and record it in Table SP 5.6.15B-1.

Ask such questions as

- How did you make your measurements?
- Who can give us a working definition of the term *dilute?* (Work for the idea that we dilute liquids by spreading them out in a larger volume of liquid by adding some other liquid to them. Put the definitions in the Working Dictionary.)
- In which of the drinks is the alcohol the most diluted? (Work for agreement that the alcohol is diluted or spread out the most in the container to which the largest volume of water was added. This was the 12-oz bottle.)
- Can you see a difference in the dilution of the drinks? What do we look for to indicate greater dilution? (Get at the color intensity—the most diluted will have the least intense color.)

- How does the total amount of alcohol in various drinks compare? Compare a 1.5-oz shot of whiskey, a 5-oz glass of wine, and a 12-oz can of beer? (Work for agreement that they all contain the same amount of alcohol.)
- How does dilution affect drinking? (Work to the idea that less alcohol is taken in with each sip of more diluted drinks and because the total volume is greater, the time over which the drink is consumed is usually longer.)

4. **Help the students use the percentages of blood alcohol concentration (BAC) in Table SP 5.6.15A-2 to determine the BAC people of different weights would have after taking various numbers of drinks.**

Ask such questions as

- How many drinks would a 50-pound person need to take in 1 hour to have a BAC of 0.10%? (This would be a little more than 1 drink.)
- Why is a 0.10% BAC important? (Get at the idea that this is the BAC used to determine whether a person is considered to be legally drunk.)
- How many drinks would a 100-pound person need to take in 1 hour to have a BAC of 0.10%? (Work for agreement that this would be a little more than 3 drinks.)
- How does body weight affect the BAC of a drinker? (Get at the idea that the more weight a person has, the less the effect of a drink on the BAC. Heavy people can drink more than lighter-weight people before their BAC reaches any given level, say 0.10%, 0.20% and so forth.)
- How does the time over which alcohol is drunk affect the drinker? (Get at the idea that the longer the period over which alcohol is drunk, the less the effect on the BAC. A person taking 4 drinks over the course of 2 hours will have a lower BAC than a person of the same weight taking them in 1 hour.)

5. **Help the students estimate the approximate number of drinks it would take a person of their body weight to reach each of the five levels of intoxication shown in Table SP 5.6.15A-3.**

Ask such questions as

- How can we find the BAC for more drinks than shown in Table 5.6.15A-2? (Help the students note that the amount in each cell of the table is a multiple of the BAC in the first cell and the number of drinks. For example, the BAC for a 150-pound person taking 8 drinks was found by multiplying 0.023% x 8, which gives 0.184%. This was rounded to 0.18%.)

- What would be the approximate BAC of a person of your weight who has taken 10 drinks in an hour? (Get at the idea of multiplying the percentage in the first cell of their weight range by 10, the number of drinks.)
- How many drinks would a person of your weight need to take in an hour to have a BAC of approximately 0.40%? (This will vary from 6–7 for students 41–65 pounds, 8–9 for students 66–90 pounds, 11–12 for students 91–115 pounds, and 13–14 for students 116-140 pounds.)

6. **Have the students use Tables SP 5.6.15A-3 and Table SP 5.6.15B to find the effect of different numbers of drinks on their minds and bodies.**

Ask such questions as

- How many drinks would you need to take in an hour to have a BAC of 0.05%? (Use this question to check the reasonableness of students' work. For most students the answer will be 1–2 drinks.)
- At what BAC does a person start to lose good judgment? (Somewhere between 0.05% and 0.10%. Some people lose control with small quantities of alcohol. This is often the case with people who are not used to drinking.)
- How many drinks would you need to take in an hour to have a BAC of 0.10%? (This would be range from a little more than 1 drink to a little more than 3 drinks for most students.)
- Describe the mental and physical behavior you would expect to have with a BAC of 0.10%? (Work for agreement that they would be clumsy, not see well, and their speech would be slurred.)
- How many drinks would be life-threatening to you? (This will be number of drinks to reach a BAC near 0.40%)
- Why is alcohol so dangerous for young children? (Get at the idea that because their bodies have little weight, a high BAC is reached with a relatively small amount of alcohol.)

EXTENSION

- Have the students report on the kinds of information found on labels of alcoholic beverages.

DASH

Name________________________

Date________________________

STUDENT PAGE 5.6.15A INTOXICATION QUESTIONS

What happens to alcohol in our body?

Alcohol that is drunk is taken into the blood mainly through the walls of the small intestine. Alcohol passes very quickly from the stomach into the small intestine. Once in the blood, it is carried to all parts of our body—our muscles, heart, liver, brain, and so forth. Here it stays until the liver can work to break it down into water and carbon dioxide. The average adult liver can process about 17.5 mL of alcohol an hour. This is about one drink an hour.

What is a "drink"?

In the alcoholic beverage industry a *drink* is a beverage that contains 0.6 oz or 17.5 mL of alcohol. This is the same amount that the average adult liver can process into water and carbon dioxide in an hour.

What are the contents of various alcoholic drinks?

Table SP 5.6.15A shows the contents of various drinks. Different kinds of drinks have different volumes, but they all contain the same amount of alcohol. A small 1.5-oz shot glass of whiskey has the same amount of alcohol as a large 12-oz bottle of beer. This is because the whiskey is 40% alcohol and the beer only 5% alcohol. See Table SP 5.6.15A-1.

How do we measure the amount of alcohol in the body of people who are drinking?

We can find out how much alcohol is in the body by taking a sample of blood. We then find out what percentage of the blood is alcohol. This percentage of alcohol in the blood is called the *blood alcohol concentration* or BAC.

A person with a BAC of 0.10% would have 0.1 mL of alcohol in each 100 mL of blood. This may seem to be a small amount of alcohol. However, in most states a person with a BAC of 0.10% is considered to be legally drunk and will be arrested if found driving a car.

Name ______________________________

Table SP 5.6.15A-1 Contents of standard drinks

Container and Type of Drink	Percentage of Alcohol in Drink	Total Volume of Drink	Volume of Alcohol in Drink
Shot glass of whiskey, vodka, or gin	40%	43.7 mL (1.5 oz)	17.5 mL (0.6 oz)
Cocktail glass of mixed drink	20%	87 mL (3 oz)	17.5 mL (0.6 oz)
Glass of wine	12%	145 mL (5 oz)	17.5 mL (0.6 oz)
Can or bottle of beer	5%	348 mL (12 oz)	17.5 mL (0.6 oz)

How many drinks does it take to produce various BACs?

We can use Table SP 5.6.15A-2 to estimate the number of drinks a person would normally have to take to reach various BACs if we know

- The drinker's weight.
- The number of drinks taken.
- The length of drinking time.

The following table shows the BACs of people of different weights who have taken various numbers of drinks in 1 hour. For example, a 50-pound person weighing who has taken 1 drink in the past hour will have a BAC of 0.06% while a 100-pound person would have had to take 2 drinks to reach the same BAC.

Name ______________________________

Table SP 5.6.15A-2 Approximate BACs of persons of different weights after taking various numbers of drinks

Weight (lb)	Approximate Blood Alcohol Concentration (BAC)*							
	1 Drink	2 Drinks	3 Drinks	4 Drinks	5 Drinks	6 Drinks	7 Drinks	8 Drinks
41–65	0.06 %	0.12 %	0.18 %	0.24 %	0.30 %	0.36 %	0.42 %	0.48 %
66–90	0.045	0.09	0.135	0.18	0.225	0.27	0.315	0.36
91–115	0.03	0.06	0.09	0.12	0.15	0.18	0.21	0.24
116–140	0.027	0.055	0.082	0.11	0.137	0.164	0.191	0.22
141–165	0.023	0.045	0.067	0.09	0.113	0.135	0.158	0.18
166–190	0.02	0.04	0.06	0.08	0.10	0.12	0.14	0.16
191–215	0.015	0.03	0.045	0.06	0.075	0.09	0.105	0.12

*Drinking time one hour

How does time affect BAC?

If a person takes 4 drinks in one hour, the BAC will be higher than it would be if the person took the same number of drinks over 2 hours. As an adult drinks, the liver removes alcohol at a fairly constant rate of about 17.5 mL per hour. That is the amount of alcohol in 1 standard drink. At the end of a 2-hour period the amount of alcohol in 2 of the drinks will have been converted to water and carbon dioxide by the liver.

How do people with different BACs react?

Table 5.6.15A-3 summarizes some common mental and physical behaviors related to the BAC of drinkers.

Name ________________________________

Table 5.6.15A-3 Common mental and physical behaviors related to BAC

Blood Alcohol Concentration (BAC)	**Mental and Physical Behaviors**
0.05%	Drinker's powers of judgment, thinking, and self-control are reduced; there is often a relaxed feeling.
0.10%	Drinker appears clumsy, visual reaction time is slowed, and speech is slurred. This is the legal limit for driving a car in many states.
0.20%	Drinker staggers, often angers easily, may shout or weep; brain centers controlling muscles work poorly
0.30%	Drinker acts in a dazed or confused way, often falls asleep.
0.40%	Drinker goes into an unconscious state called a coma. Death may occur.
0.50%	Drinker dies unless immediate medical aid is received.

DASH

Name ______________________

Date ______________________

STUDENT PAGE 5.6.15B INTOXICATION

1. Record the volume of water that was added to dilute each 17.5 mL (0.6 oz) of simulated alcohol in the drinks shown in the table below.

Container and simulated drink	Total volume of drink	Volume of simulated alcohol in drink	Volume of diluting water added
Shot glass of 80-proof whiskey, vodka, or gin	43.5 mL (1.5 oz)	17.5 mL (0.6 oz)	________
Cocktail glass of mixed drink	87.0 mL (3.0 oz)	17.5 mL (0.6 oz)	________
Glass of wine	145.0 mL (5.0 oz)	17.5 mL (0.6 oz)	________
Can or bottle of beer	348.0 mL (12.0 oz)	17.5 mL (0.6 oz)	________

2. Explain how you found the volume of diluting water to add.

____

____

____

____

____

Name ______________________

3. **Use the information in Table SP 5.6.15A-2 to calculate the approximate number of drinks a person of your weight would have to take in 1 hour to reach the BACs shown in the table below.**

Weight: ....lb	**Blood Alcohol Concentration (BAC)**				
	0.05%	**0.10%**	**0.20%**	**0.30%**	**0.40%**
Number of drinks taken in 1 hour					

ACTIVITY 5.6.16 DRUG LAWS

OBJECTIVES

The students
- Are introduced to the concept that some therapeutic drugs are abused.
- Are introduced to the logic for the Federal Drug Schedule.
- Are introduced to and practice using the technical language of the U.S. Drug Enforcement Administration.

BACKGROUND

This activity completes the drug, alcohol, and tobacco series for DASH 5. It should follow Activity 5.6.15 INTOXICATION if possible. DRUG LAWS is designed to point out that many drugs have therapeutic value, but if abused they can be destructive, potentially leading to addiction, psychological damage, and even death.

Language

As with all technical areas there is a special language used with drugs. There is also the ever changing language of the street. In this activity the students become acquainted with technical language they can use with members of the medical profession, social workers, and other professionals. To gain understanding of the uses and effects of drugs, the reasons for drug laws, and the language of drugs, they make question cards and play the Drug Law Game.

Street Dictionary

An informative activity is to have the students make a “street dictionary” of terms commonly heard in the non-technical world. This will help you talk to the students about drugs more effectively.

Recent Drug Laws

In 1996 California and Arizona took a stance challenging the U.S. government's control of marijuana. They have passed laws making marijuana available through a doctor's prescription to persons suffering the effects of chemotherapy and certain diseases such as AIDS. The status of this legislation can be followed in the Drug Scrapbook. To guide the students have them focus on the way that a democratic society makes decisions.

Game Cards

In this activity the students are first given background information about the history of drug legislation in the United States. See Student Page 5.6.16 DRUG LAWS. The students add information from Student Pages 5.6.7 TOBACCO QUIZ and 5.6.11 ALCOHOL QUIZ. From this they make *true-false* or *multiple-choice* question-and-answer cards for the Drug Law Game. The work can be done in small groups, and the card deck can be assembled for large entire-class or small-groups. Duplication in cards will help in the learning reinforcement process.

The students are also given the U.S. Drug Enforcement Administration's table of the uses and effects of controlled substances. From this they make a second set of game cards.

The Drug Law Game

Organization of the game can be handled in two ways:

Entire Class

- Divide the class into teams of 4 to 6 students.
- One student acts as reader. Alternative: The teacher acts as reader.
- The reader draws a card from the top of a shuffled deck and gives the first team the opportunity to answer the question.
- If the answer is correct, the team gets a point, and the card is put in the *answered pile.* If the answer is incorrect, the card is put on the bottom of the pile for later replay without giving the answer.
- The reader draws another card and follows the same procedure with each successive team.

Play several rounds of the game.

Suggestions for play

In the first two rounds have the students find the answers in the Student Pages within a limited time, for example, 10 seconds. Thereafter have the students play the game from memory.

Small group

- Divide the class into groups of 5, 7, or 9 students. Further divide the groups into teams of 2 students.
- Have one student act as reader.
- Use the same procedure as with the entire class.

STUDENT ROLE

Drug-aware citizen

MATERIALS

timer (optional)
3 x 5-in cards
Student Pages 5.6.7 TOBACCO QUIZ
5.6.11 ALCOHOL QUIZ
5.6.16 DRUG LAWS

PRODUCTS

Drug Law Game cards
Dictionary of Street Drug Language

PROCEDURES

1. **Help the students make a concept map about the term *drug.***

   Help them include such things as
   - Medicine.
   - Drugstore.
   - Prescription.
   - Various therapeutic drugs (aspirin, Tylenol, cough medicines, and so forth).
   - Illegal drugs, abused drugs, recreational drugs.
   - Drug dealers.
   - Various illegal drugs (cocaine, PCP, marijuana, and so forth).

3. **Introduce Student Page 5.6.16 DRUG LAWS. Discuss the information.**

4. **Have the students work in groups of 4 to make 8 or 10 cards with true-false or multiple-choice questions using Student Pages 5.6.16 DRUG LAWS, 5.6.7 TOBACCO QUIZ, and 5.6.11 ALCOHOL QUIZ.**

   Have them
   - Put one question on the front of a card.
   - Put one answer on the back of the card.
   - Initial the cards.

5. **Play a preliminary round of the Drug Law Game using the first deck of cards. See Background.**

6. **Give the students the table of uses and effects of controlled substances found in Student Page 5.6.16. Have the same groups make a second deck of cards with 4 or 5 true-false or multiple-choice questions per group.**

7. **Have the students play a competition match of the Drug Law Game using both decks of cards.**

8. **Summarize the implications of the game.**

   Ask such questions as
   - What is the difference between abuse and therapeutic use of drugs?
   - Why are drugs controlled by U.S. Drug Enforcement Agency?
   - What is drug addiction? (Work to the ideas that *addiction* is a state of drug dependency and a drug-dependent person has a craving for a drug and will suffer withdrawal symptoms or physical illness if deprived of the drug.)
   - Why is addiction so devastating? (This is a chance to get at the problem of the high cost of illegal drugs, the danger of getting an overdose, the danger of suffering long-term brain or other body damage, and so forth.)

9. **Have the students begin a dictionary of street drug language. Periodically go to this dictionary and help them relate the words written there to the technical language of the medical profession. Some of this language may come from the Drug Scrapbook.**

EXTENSIONS

- Put the Drug Law Game in an interest center and encourage the students to play the game at will.
- Have the students add cards to the game as they find out more about drugs.
- Have the students compete in Drug Law "olympic" games at the end of the year.
- Invite a law enforcement officer to talk about local drug laws, particularly the laws concerning possession and use.

DASH

Name________________________

Date________________________

STUDENT PAGE 5.6.16 DRUG LAWS

QUESTIONS ABOUT DRUGS

What are drugs?
Drugs are chemical substances other than nutrients (foods, vitamins, minerals, and water). When taken into our body, they help fight disease or change the way our body works. Drugs include such substances as aspirin, penicillin, and cough syrups as well as more commonly abused drugs.

What is drug abuse?
Drug abuse refers to use of a drug for a purpose different from the one intended by doctors or hospitals who would prescribe it. Abuse may result in dependency where one craves the drug.

What is drug addiction?
Drug addiction or drug dependency occurs when after using a drug a person develops a craving or desire and need for it. When drug-dependent persons try to stop using the drug, they can suffer psychologically and physically, often becoming ill.

What kinds of drugs are abused?
The main drugs that are abused are classified as *narcotics, stimulants, depressants, hallucinogens*, and *cannabis.* Most of the drugs that are abused are also used for medical purposes.

What are narcotic drugs?
Narcotics are painkillers, also called *analgesics.* Originally the term "narcotics" referred to drugs derived from opium.

What is opium?
Opium is a mixture of drugs that come from a fluid produced by the poppy *Papaver somniferum.* Raw opium contains two major narcotics or painkillers, *morphine* and *codeine.* Other drugs are also made by altering

Name ____________________

the chemical structure of the natural compounds in opium. A common manufactured drug is *heroin*, which is made from morphine.

What are synthetic narcotics?
Synthetic narcotics are compounds that are painkillers but are not derived from opium. These include *methadone*.

What are depressants?
Depressants, or *sedatives*, are used to calm the nerves and bring sleep. They are commonly called "downers." Depressants include alcohol and Valium.

What are stimulants?
Stimulants are drugs that give a feeling of strength and alertness. They are commonly called "uppers." These include *caffeine, cocaine, crack,* and *amphetamines*.

What are hallucinogens?
Hallucinogens are drugs that produce distortions of reality. Often terrifying, misshapen figures and objects appear along with wild displays of color. Two common hallucinogenic drugs are *LSD* and *PCP*.

What is cannabis?
Cannabis is any drug extracted from the hemp plant (*Cannabis sativa*). These drugs produce a sense of calm and relaxation. The most common cannabis drugs are *marijuana* and *hashish*.

What is the history of drug legislation in the United States?
The damaging effect of various drugs has been recognized by the U.S. Congress since early in this century. In 1914 Congress passed the Harrison Narcotic Act, which established federal control of heroin. Manufacture, sale, and transportation of drinking alcohol within the United States was prohibited by the 18th or Liquor Prohibition Amendment to the U.S. Constitution. This amendment was ratified by the states in 1919 but was repealed in 1933 by the 21st Amendment. Marijuana came under federal control in 1937. Since then there has been additional state and federal legislation to regulate the use of drugs.

What is the Controlled Substance Act?
In 1970 the U.S. Congress passed the Controlled Substance Act (CSA). This act established the criteria for classifying how drugs can be legally dispensed.

Name ______________________

How do federal agencies determine whether a drug should be controlled?

The following questions are asked when the status of a drug is determined:

- What is the potential for abuse of the drug?
- What do we know about how the drug works in the body?
- What other scientific knowledge do we have about the drug?
- What is the history and what are the present patterns of the drug's abuse?
- How significant are the effects of the drug's abuse?
- What are the risks to public health when the drug is used?
- What is the probability of drug dependency?
- Can other controlled drugs be easily made from the drug?

How does the Federal Drug Enforcement Administration control drugs?

Drugs are controlled by regulating their distribution by drugstores, hospitals, and doctors. Drugstores, hospitals, and doctors are made responsible for seeing that drugs are given only to persons who have a medical need for them. The way drugs are regulated depends on how they are classified in the Federal Drug Schedule.

What is the Federal Drug Schedule?

The federal government has classified drugs according to their potential for abuse. The federal classification fits drugs within one of five schedules. The most potentially dangerous drugs are in Schedule I, the least dangerous in Schedule V.

What are SCHEDULE I drugs?

Drugs that come under SCHEDULE I classification have some or all of the following characteristics:

- They have no acceptable medical use in the United States now.
- There is no safe way to supervise their use.
- There is great danger for abuse, including high potential for physical and psychological dependency.
- They are used for research only.

Examples are heroin, LSD, and marijuana.

What are SCHEDULE II drugs?

Drugs that come under SCHEDULE II classification have the following characteristics:

- They have acceptable medical use.
- Their use can be safely supervised.

Name ____________________

- There is great danger from abuse, including high potential for physical and psychological dependency.
- A doctor's prescription is required with no refills. Prescriptions for resupply must be made separately.

Examples are cocaine and amphetamines.

What are SCHEDULE III drugs?

Drugs that come under SCHEDULE III classification have the following characteristics:

- They have acceptable medical use.
- Their use can be safely supervised.
- There is danger from abuse, including moderate potential for physical dependency and high potential for psychological dependency.
- A doctor's prescription is required with refills allowed.

Examples are glutethimide and tetrahydrocannibinol.

What are SCHEDULE IV drugs?

Drugs that come under SCHEDULE IV classification have the following characteristics:

- They have acceptable medical use.
- Their use can be safely supervised.
- There is a danger from abuse, including low potential for physical dependency but high potential for psychological dependency.
- A doctor's prescription is required with refills allowed.

Examples are Librium and Valium.

What are SCHEDULE V drugs?

Drugs that come under SCHEDULE V classification have the following characteristics:

- They have acceptable medical use.
- Their use can be safely supervised.
- There is a danger from abuse including low levels of both physical and psychological dependency.
- A doctor's prescription is required with refills allowed.

Examples are Darvon and Tylenol with codeine.

Controlled Substances - Uses & Effects

DRUGS/CSA SCHEDULES		TRADE OR OTHER NAMES	MEDICAL USES	DEPENDENCE		TOLERANCE	DURATION (Hours)	USUAL METHODS OF ADMINISTRATION	POSSIBLE EFFECTS	EFFECTS OF OVERDOSE	WITHDRAWAL SYNDROME
				Physical	Psychological						
NARCOTICS											
Opium	II III IV	Dover's Powder, Paregoric, Parepectolin	Analgesic, Antidiarrheal	High	High	Yes	3-6	Oral, smoked	Euphoria, drowsiness, respiratory depression, constricted pupils, nausea	Slow and shallow breathing, clammy skin convulsions, coma, possible death	Watery eyes, runny nose, yawning, loss of appetite, irritability, tremors, panic cramps, nausea chills and sweating
Morphine	II III	Morphine, MS-Contin, Roxanol, Roxanol-SR	Analgesic, Antitussive	High	High	Yes	3-6	Oral, smoked, injected			
Codeine	II III V	Tylenol w/Codeine, Empirin w/Codeine Robitussan A-C, Fiorinal w/Codeine	Analgesic, Antitussive	Moderate	Moderate	Yes	3-6	Oral, injected			
Heroin	I	Diacetylmorphine, Horse, Smack	None	High	High	Yes	3-6	Injected, sniffed, smoked			
Hydromorphone	II	Dilaudid	Analgesic	High	High	Yes	3-6	Oral, injected			
Meperidine(Pethidine)	II	Demerol, Mepergan	Analgesic	High	High	Yes	3-6	Oral, injected			
Methadone	II	Dolophine, Methadone, Methadose	Analgesic	High	High-Low	Yes	12-24	Oral, injected			
Other Narcotics	I II III IV V	Numorphan, Percodan, Percocet, Tylox Tussionex, Fentanyl, Darvon, Lomotil, Talwin	Analgesic, antidiarrheal, antitussive	High-Low	High-Low	Yes	Variable	Oral, injected			
DEPRESSANTS											
Chloral Hydrate	IV	Noctec	Hypnotic	Moderate	Moderate	Yes	5-8	Oral	Slurred speech, disorientation, drunken behavior without the odor of alcohol	Shallow respiration, clammy skin, dilated pupils, weak and rapid pulse, coma, possible death	Anxiety, insomnia, tremors, delirium, convulsions, possible death
Barbiturates	II III IV	Amytal, Butisol, Fiorinal, Lotusate, Nembutal, Seconal, Tuinal, Phenobarbital	Anasthetic, Anticonvulsant, sedative, hypnotic, veterinary euthanasia agent	High-Mod.	High-Mod.	Yes	1-16	Oral			
Benzodiazepines	IV	Ativan, Dalmane, Diazepam, Librium, Xanax, Serax, Valium, Tranxexe, Verstran, Versed, Halcion, Paxipam, Restoril	Antianxiety, anti-convulsant, sedative, hypnotic	Low	Low	Yes	4-8	Oral			
Methaqualone	I	Quaalude	Sedative, hypnotic	High	High	Yes	4-8	Oral			
Glutethimide	III	Doriden	Sedative, hypnotic	High	Moderate	Yes	4-8	Oral			
Other Depressants	III IV	Equanil, Miltown, Noludar, Placidyl, Valmid	Antianxiety, sedative, hypnotic	Moderate	Moderate	Yes	4-8	Oral			
STIMULANTS											
Cocaine	II	Coke, Flake, Snow, Crack	Local anesthetic	Possible	High	Yes	1-2	Sniffed, smoked, injected	Increased alertness, excitation, euphoria, increased pulse rate & blood pressure, insomnia, loss of appetite	Agitation, increase in body temperature, hallucinations, convulsions, possible death	Apathy, long periods of sleep, irritability depression, disorientation
Amphetamines	II	Biphetamine, Delcobese, Desoxyn, Dexedrine, Obetrol	Attention deficit disorders, narcolepsy, weight control	Possible	High	Yes	2-4	Oral, injected			
Phenmetrazine	II	Preludin	Weight control	Possible	High	Yes	2-4	Oral, injected			
Methylphenidate	II	Ritalin	Attention deficit disorders, narcolepsy	Possible	High	Yes	2-4	Oral, injected			
Other Stimulants	III IV	Adipex, Cylert, Didrex, Ionamin, Melfiat, Plegine, Sanorex, Tenuate, Tepanil, Prelu-2	Weight control	Possible	High	Yes	2-4	Oral, injected			
HALLUCINOGENS											
LSD	I	Acid, Microdot	None	None	Unknown	Yes	8-12	Oral	Illusions and hallucinations, poor perception of time and distance	Longer, more intense "trip" episodes, psychosis, possible death	Withdrawal syndrome not reported
Mescaline and Peyote	I	Mexc, Buttons, Cactus	None	None	Unknown	Yes	8-12	Oral			
Amphetamine Variants	I	2,5-DMA, PMA, STP, MDA, MDMA, TMA, DOM, DOB	None	Unknown	Unknown	Yes	Variable	Oral, injected			
Phencyclidine	II	PCP, Angel Dust, Hog	None	Unknown	High	Yes	Days	Smoked, oral, injected			
Phencyclidine Analogues	I	PCE, PCPy, TCP	None	Unknown	High	Yes	Days	Smoked, oral, injected			
Other Hallucinogens	I	Bufotenine, Ibogaine, DMT, DET, Psilocybin Psilocyn	None	None	Unknown	Possible	Variable	Smoked, oral, injected			
CANNABIS											
Marijuana	I	Pot, Acapulco Gold, Grass, Reefer, Sinsemilla, Thai Sticks	None	Unknown	Moderate	Yes	2-4	Smoked, oral	Euphoria, relaxed inhibitions, increased appetite, disoriented behavior	Fatigue, paranoia, possible psychosis	Insomnia, hyperactivity, and decreased appetite occasionally reported
Tetrahydrocannabinol	I II	THC, Marinol	Cancer chemotherapy, antinauseant	Unknown	Moderate	Yes	2-4	Smoked, oral			
Hashish	I	Hash	None	Unknown	Moderate	Yes	2-4	Smoked, oral			
Hashish Oil	I	Hash Oil	None	Unknown	Moderate	Yes	2-4	Smoked, oral			

Source: U.S. Drug Enforcement Adm.

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DASH

Name__________________________

Date__________________________

STUDENT PAGE 5.6.1A GROWTH CHART

Record your height, weight or mass, and the area of your hand and foot. Use any Growth Chart already in your Science Record Book or if the pages are getting worn, transfer data from your Science Record Book to the table below.

		HEIGHT				WEIGHT/MASS			
GRADE	MO/YR	cm	*Change	in	*Change	lb	*Change	kg	*Change

		HAND AREA		FOOT AREA	
GRADE	MO/YR	cm^2	*Change	cm^2	*Change

*Change since last measurement

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SP 5.6.1B METRIC GRID

Name ______________________

Date ______________________

DASH

Name__________________________

Date___________________________

STUDENT PAGE 5.6.1C AREA MEASUREMENT

THE METRIC SYSTEM AND AREA MEASUREMENT

Once the meter and centimeter had been defined, it became possible to set standard units for measuring area. The *area* of a thing is the measure of its surface. A *surface* is what we feel when we pass our hands over something that is solid. It is usually the outside of things. A surface may also be the outer boundary of a liquid. For example, we swim at the surface of water.

The size of a surface is called an *area*. The most common units of area in the metric system that we will deal with are the *square centimeter* and the *square meter*. Figure SP 5.6.1C(1) shows a centimeter square. It is just what it sounds like, a square that measures 1 centimeter on each side. A square meter is a square measuring 1 meter on each side.

COMMON METRIC UNITS OF AREA	ABBREVIATIONS
square centimeter	cm^2
square meter	m^2
square kilometer	km^2

The raised *2* or superscript tells us we are using squares. We read "cm^2" as "centimeter squared" or "square centimeter."

Measuring Regular Geometric Surfaces

It is easy to measure the area of rectangular things using a piece of grid paper marked off in centimeter squares. In Figure SP 5.6.1C(2) Rectangle A has 6 centimeter squares in it, Rectangle B has 9, and Rectangle C has 12. Another method of finding area is to multiply the number of squares along the length of the rectangle by the number along the width.

AREA = LENGTH X WIDTH

Name ______________________

Sometimes a rectangle we are measuring does not completely cover all the centimeter squares that it overlays. When this happens, we can estimate the fraction or measure it. See Figure SP 5.6.1C(3).

Area of Irregular Surfaces

Surfaces may not be rectangular, but we can still get a very good estimate of their area using a grid. We simply place the grid paper over the surface, count the number of full squares, and then estimate the area covered by the others. See Figure SP 5.6.1C(4). Here there are 9 full centimeter squares and 6 that are about one-half a square centimeter.

The U.S. System of Area Measurement.

Area measurement in the English system in the United States is done the same way as it is in the metric system. Some common units of area are the square inch, the square foot, the square yard, and the square mile.

COMMON U.S. UNITS OF AREA	ABBREVIATIONS
square inch	in^2
square foot	ft^2
square yard	yd^2
square mile	mi^2

ILLUSTRATIONS

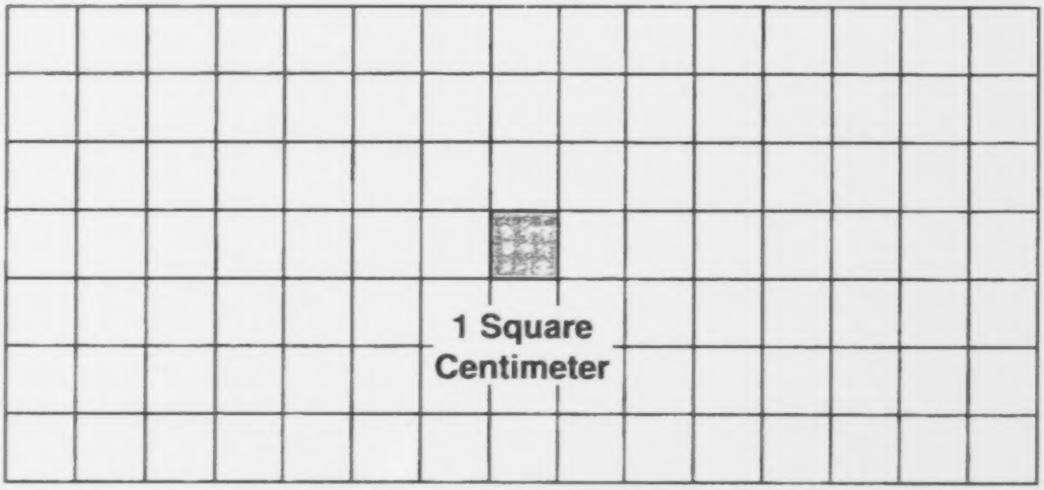
1 Square
Centimeter

Figure SP 5.6.1C(1) Square centimeter

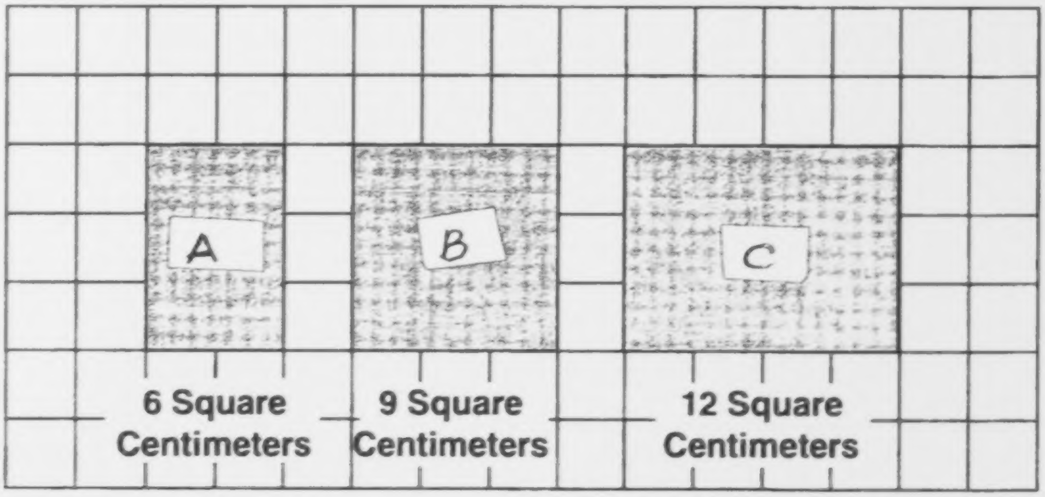
A
B
C
6 Square
Centimeters
9 Square
Centimeters
12 Square
Centimeters

Figure SP 5.6.1C(2) Use of a grid to measure the area of rectangles with whole numbers of square centimeters

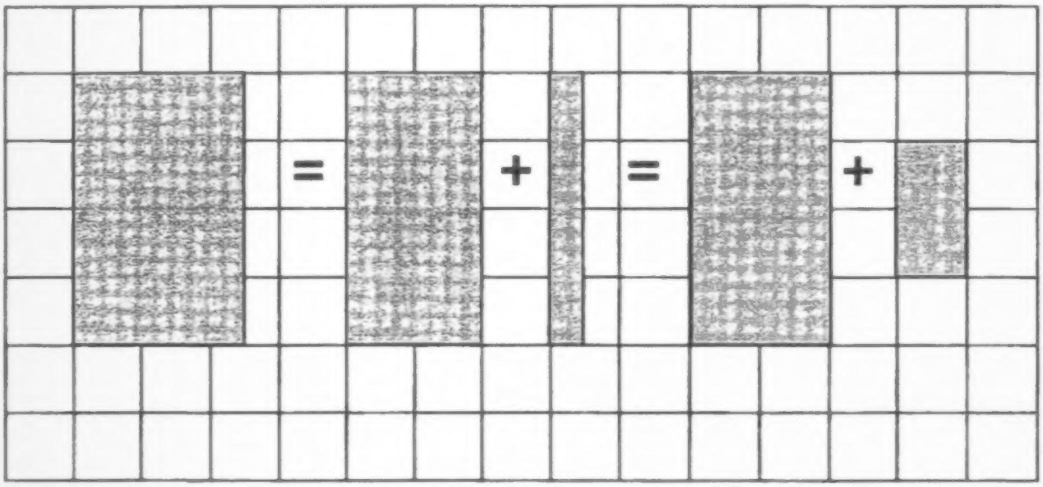

Figure SP 5.6.1C(3) Use of a grid to measure the area of a rectangle that does not have a whole number of centimeter squares

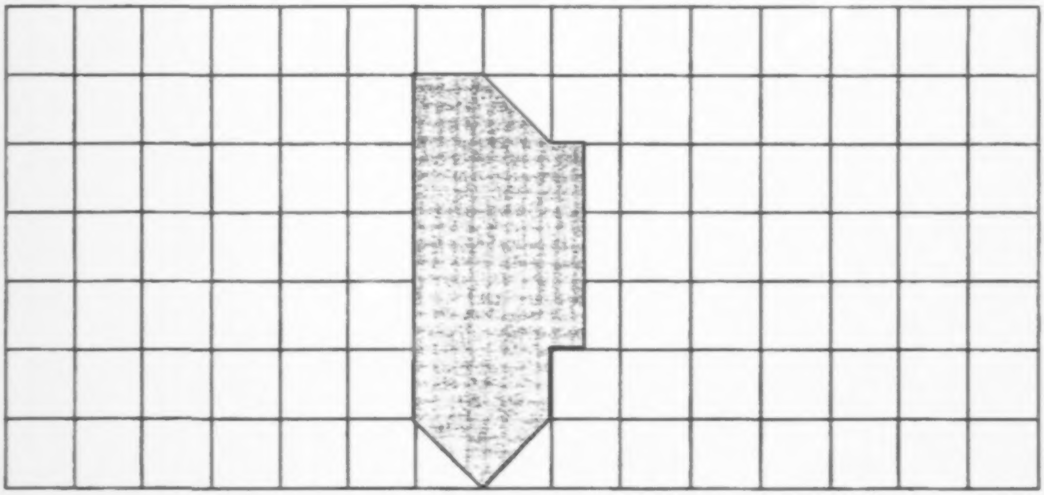

Figure SP 5.6.1C(4) Use of a grid to determine the area of an irregular surface

Name__________________________

Date__________________________

DASH

STUDENT PAGE 5.6.2 TOOTH CHART

Record the status of your teeth on the Tooth Chart below.

- Circle the picture of each tooth you cannot find.
- Blacken in any gap due to a lost tooth.
- Put an *(X)* on all teeth that have cavities, fillings, or caps.

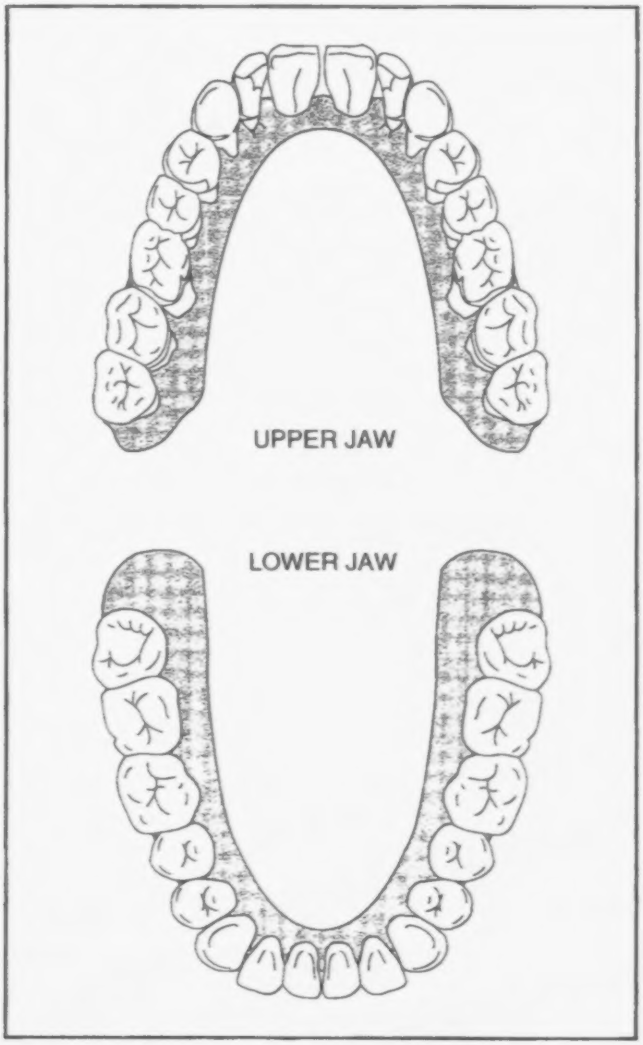

Figure SP 5.6.2 Tooth chart

SP 5.6.2-2

Name ____________________

TOOTH INVENTORY			
	MY COUNT	TOTAL CLASS COUNT	AVERAGE CLASS COUNT
Number of Teeth			
Number of Teeth Lost			
Number of Teeth Gained			
Number of Cavities			
Number of Cavities in Old Teeth			
Number of Cavities in New Teeth			

Name____________________

Date____________________

STUDENT PAGE 5.6.3 SAFETY DEVICES

1. Draw your design for an eye shield to protect against liquids.

2. List your safety rules.

DASH

Name____________________________

Date____________________________

STUDENT PAGE 5.6.4 ALCOHOL TOBACCO, AND DRUGS

1. List your questions about alcohol, tobacco, and drugs.

2. List answers to your questions about alcohol, tobacco, and drugs.

Name______________________

Date______________________

DASH

STUDENT PAGE 5.6.5 SEXUALLY TRANSMITTED DISEASES

1. List your questions about sexually transmitted diseases.

2. List answers to your questions.

DASH

Name______________________

Date______________________

STUDENT PAGE 5.6.6
SEXUALLY TRANSMITTED DISEASES QUIZ

1. List your quiz questions about sexually transmitted diseases.

2. List the answers to your quiz.

DASH

Name__________________________

Date__________________________

STUDENT PAGE 5.6.7 THE TOBACCO QUIZ

1. **Tobacco first came from**
   a) Asia b) Europe
   c) Africa d) America

2. **Tobacco was first introduced as medicine.**
   True False

3. **In the United States tobacco is the most profitable major crop per acre.**
   True False

4. **The United States is the world's largest exporter of tobacco.**
   True False

5. **The United States is the world's largest producer of tobacco.**
   True False

6. **When was tobacco first recognized as a health hazard by the U.S. Government?**
   a)1832 b) 1864 c) 1932 d) 1964 e) 1984

7. **What diseases were first identified with use of tobacco?**
   a) heart disease d) bronchitis
   b) emphysema e) peptic ulcers
   c) lung cancer

8. **When was tobacco advertisement first banned from radio and TV?**
   a)1832 b) 1864 c) 1932 d) 1964 e) 1984

Name ______________________

9. **Tobacco is a major source of tax revenue in the United States.**
   True False

10. **Tobacco is a major source of employment in the United States.**
    True False

11. **What is the legal age for smoking in the different states?**
    a) Varies b) 18 c) 21

12. **Tobacco use is addictive.**
    True False

13. **Smoking by expectant mothers is a health hazard for unborn babies.**
    True False

14. **When used by humans all forms of tobacco pose a health hazard.**
    True False

15. **Smoking is not only dangerous to smokers but also to those who breathe secondhand smoke.**
    True False

16. **Less than one-third of the adult U.S. population smoke regularly.**
    True False

17. **There has been a steady decrease in the number of cigarettes smoked per person in the United States since 1982.**
    True False

Name________________________

Date________________________

DASH

STUDENT PAGE 5.6.8 SMOKERS' SURVEY

1. Attach the list of questions you used in your survey.
2. Attach a record of the answers you got to your questions.
3. Calculate the cost of a cigarette. Cost per cigarette ______
4. Calculate the number of cigarettes smoked by the people you interviewed and their cost per day and year. Record your data in the table below.

Person interviewed	Number of cigarettes per day	Number of cigarettes per year	Cost per day	Cost per year
# 1				
# 2				
# 3				
# 4				
# 5				

SP 5.6.8-2

Name ____________________

5. Use the class data to calculate the average number of cigarettes smoked in a year by the males and females according to their age range (child–19 years, 20–39 years, 40 years and older). Record your data on the table below.

Gender	Average Number of Cigarettes per Year		
	(child–19 yr)	*(20-39 yr)*	*(40 yr & older)*
Females			
Males			

6. Make a bar graph showing the average number of cigarettes smoked in a year by the males and females according to their age range (child–19 years, 20–39 years, 40 years and older).

7. Use the class data to calculate the average cost of the cigarettes smoked in a year by the females and males according to their age range. Record your data on the table below.

Gender	Average Cost of Cigarettes per Year		
	(child–19 yr)	*(20-39 yr)*	*(40 yr & older)*
Females			
Males			

Name ____________________

8. Make a bar graph showing the average cost per year of cigarettes smoked by the males and females in the three age ranges (child–19 years, 20–39 years, 40 years and older).

9. Calculate the percentage of smokers in each age range who agreed with the responses to health questions shown in the table below.

Responses to Health Questions	Percentage of Responses *(child-19 yr)*	 *(20–39 yr)*	 *(40 yr & older)*
• Know about the health hazards of smoking and believe them			
• Know about the health hazards of smoking and do not believe them			
• Want to stop smoking			
• Have tried to stop smoking			
• Feel that smoking is adversely affecting their health			
• Would recommend that you take up smoking			
• Would recommend that you not take up smoking			

Name ____________________

10. Comment on other statistics from your survey that you feel are important.

11. What do these statistics do to help you make decisions about smoking?

Name ______________________

DASH

Name________________________

Date________________________

STUDENT PAGE 5.6.9 EX-SMOKERS' SURVEY

1. Attach the list of questions you used in your survey.
2. Attach a record of the answers you got to your questions.
3. Calculate the cost of a cigarette. Cost per cigarette ___
4. Calculate the number of cigarettes smoked by the ex-smokers you interviewed and their cost per day and year. Record your data in the table below.

Ex-smoker interviewed	Number of cigarettes per day	Number of cigarettes per year	Cost per day	Cost per year
# 1				
# 2				
# 3				
# 4				
# 5				

Name________________________

5. Use the class data to calculate the average number of cigarettes smoked in a year by male and female ex-smokers according to their age range (child–19 years, 20–39 years, 40 years and older). Record your data on the table below.

Gender	Average Number of Cigarettes per Age Group *(child–19 yr)*	*(20–39 yr)*	*(40 yr & older)*
Females			
Males			

6. Make a bar graph showing the average number of cigarettes smoked in a year by male and female ex-smokers according to their age range (child–19 years, 20–39 years, 40 years and older).

7. Use the class data to calculate the average cost of the cigarettes smoked in a year by female and male ex-smokers according to their age range. Record your data on the table below.

Gender	Average Cost of Cigarettes per Age Range *(child–19 yr)*	*(20-39 yr)*	*(40 yr & older)*
Females			
Males			

Name______________________________

8. Make a bar graph showing the average cost per year of cigarettes smoked by male and female ex-smokers in the three age ranges (child–19 years, 20–39 years, 40 years and older).

9. Calculate the percentage of ex-smokers in each age range who agreed with the responses to the health questions shown in the table below.

Responses to Health Questions	Percentage per Age Range *(child–19 yr)*	*(20–39 yr)*	*(40 yr & older)*
• Knew about the health hazards of smoking and believed them			
• Know about the health hazards of smoking and do not believe them			
• Wanted to stop smoking			
• Tried to stop smoking several times before succeeding			
• Felt that smoking was adversely affecting their health			
• Would recommend that you take up smoking			
• Would recommend that you not take up smoking			

10. Comment on other statistics from your survey that you feel are important.

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Name______________________________

11. What do these statistics do to help you make decisions about smoking?

Name ______________________________

Name________________________

Date________________________

DASH

STUDENT PAGE 5.6.10 SMOKING LAWS

1. List government and other law-making groups in order of the number of people they serve. Start with the United States Congress.

2. What laws, if any, have each of these law-making groups made about smoking?

3. List the things you can do when someone breaks a smoking law.

Name ______________________

4. What is meant by the statement that to enjoy good health and safety we must learn the facts that are available about health and safety?

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5. What is meant by the statement that to make good health decisions we should be sure of the reliability of our information?

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6. What is meant by the statement that we need to use information about health and safety effectively?

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Name ______________________

7. **What is meant by the statement that we can make considered decisions about health and safety by selecting actions that are most likely to produce the most favorable consequences?**

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8. **What is meant by the statement that we need to get to know other people who act on matters of health and safety on the basis of knowledge and reason?**

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9. **What is meant by the statement that we need to remember why we have made a decision to do or not do something?**

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DASH

Name__________________________

Date__________________________

STUDENT PAGE 5.6.11 ALCOHOL QUIZ

ALCOHOL QUIZ

1. **Alcohol is a natural product of yeast acting on fruit juices or other sugar solutions.**
   True False

2. **Alcohol is a drug that affects the nervous system, and it has been used as an anesthetic for centuries.**
   True False

3. **To the yeast that produce it, alcohol**
   a) Is a waste b) Is a poison c) Is lethal d) All of the preceding

4. **People who become drunk lose control over their nervous system.**
   True False

5. **Sale of alcoholic drinks has always been legal in the United States.**
   True False

6. **The more body mass people have, the more alcohol they can handle before showing signs of drunkenness.**
   True False

7. **A person who is a regular long-time drinker takes longer to get "high" than a person who has just started drinking.**
   True False

8. **A person may get "high" on a single can of beer or glass of wine.**
   True False

Name ______________________________

9. Extended use of alcohol may produce

a) Liver damage	d) Heart damage
b) Brain damage	e) Cancer
c) Kidney damage	f) All of the preceding

10. Alcohol is involved in a large proportion of fatal automobile accidents.
True False

11. What is the legal age for drinking in your state?
a) Any age b) 18 c) 21

12. Alcohol use can be addictive.
True False

13. The drinking of alcoholic beverages by expectant mothers is a health risk for the unborn babies.
True False

14. About 10 percent of the adult population is alcohol-dependent.
True False

15. Breaking addiction to alcohol usually requires professional help.
True False

16. Alcohol is a common solvent in medicines.
True False

17. The percentage of smokers that become addicted to tobacco is greater than the percentage of drinkers that become addicted to alcohol.
True False

18. Child and spouse abuse, crime, automobile wrecks, and loss of jobs are often associated with alcohol use but not with the use of tobacco.
True False

DASH

Name________________________

Date________________________

STUDENT PAGE 5.6.12 ALCOHOL LAWS

1. List laws about alcohol that came from the federal government.

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2. List laws about alcohol that came from your state government.

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3. List laws about alcohol that came from your city government.

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4. List rules about alcohol that came from your school board.

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Name ______________________

5. What is meant by the statement that the success of a rule or law is often determined more by how much people believe in it than the way that it is enforced?

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6. What is meant by the statement that laws and rules are essential to making our society work?

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7. What is meant by the statement that by finding out why rules and laws were made we can better support them?

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8. What is meant by the statement that rules and laws about alcohol and tobacco are needed to make our society healthy and safe?

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Name________________________

Date________________________

DASH

STUDENT PAGE 5.6.13 CHRIS'S STORY

List the things Chris should have learned from going to the party.

DASH

Name__________________________

Date__________________________

STUDENT PAGE 5.6.14 THE PARENTS' STORY

Write a scenario about the building of a positive relationship between Chris and her family in the days after the party.

DASH

Name________________________

Date________________________

STUDENT PAGE 5.6.15A INTOXICATION QUESTIONS

What happens to alcohol in our body?
Alcohol that is drunk is taken into the blood mainly through the walls of the small intestine. Alcohol passes very quickly from the stomach into the small intestine. Once in the blood, it is carried to all parts of our body—our muscles, heart, liver, brain, and so forth. Here it stays until the liver can work to break it down into water and carbon dioxide. The average adult liver can process about 17.5 mL of alcohol an hour. This is about one drink an hour.

What is a "drink"?
In the alcoholic beverage industry a *drink* is a beverage that contains 0.6 oz or 17.5 mL of alcohol. This is the same amount that the average adult liver can process into water and carbon dioxide in an hour.

What are the contents of various alcoholic drinks?
Table SP 5.6.15A shows the contents of various drinks. Different kinds of drinks have different volumes, but they all contain the same amount of alcohol. A small 1.5-oz shot glass of whiskey has the same amount of alcohol as a large 12-oz bottle of beer. This is because the whiskey is 40% alcohol and the beer only 5% alcohol. See Table SP 5.6.15A-1.

How do we measure the amount of alcohol in the body of people who are drinking?
We can find out how much alcohol is in the body by taking a sample of blood. We then find out what percentage of the blood is alcohol. This percentage of alcohol in the blood is called the *blood alcohol concentration* or BAC.

A person with a BAC of 0.10% would have 0.1 mL of alcohol in each 100 mL of blood. This may seem to be a small amount of alcohol. However, in most states a person with a BAC of 0.10% is considered to be legally drunk and will be arrested if found driving a car.

Name ______________________________

Table SP 5.6.15A-1 Contents of standard drinks

Container and Type of Drink	**Percentage of Alcohol in Drink**	**Total Volume of Drink**	**Volume of Alcohol in Drink**
Shot glass of whiskey, vodka, or gin	40%	43.7 mL (1.5 oz)	17.5 mL (0.6 oz)
Cocktail glass of mixed drink	20%	87 mL (3 oz)	17.5 mL (0.6 oz)
Glass of wine	12%	145 mL (5 oz)	17.5 mL (0.6 oz)
Can or bottle of beer	5%	348 mL (12 oz)	17.5 mL (0.6 oz)

How many drinks does it take to produce various BACs?

We can use Table SP 5.6.15A-2 to estimate the number of drinks a person would normally have to take to reach various BACs if we know

- The drinker's weight.
- The number of drinks taken.
- The length of drinking time.

The following table shows the BACs of people of different weights who have taken various numbers of drinks in 1 hour. For example, a 50-pound person weighing who has taken 1 drink in the past hour will have a BAC of 0.06% while a 100-pound person would have had to take 2 drinks to reach the same BAC.

Name ______________________________

Table SP 5.6.15A-2 Approximate BACs of persons of different weights after taking various numbers of drinks

Weight (lb)	Approximate Blood Alcohol Concentration (BAC)* 1 Drink	2 Drinks	3 Drinks	4 Drinks	5 Drinks	6 Drinks	7 Drinks	8 Drinks
41–65	0.06 %	0.12 %	0.18 %	0.24 %	0.30 %	0.36 %	0.42 %	0.48 %
66–90	0.045	0.09	0.135	0.18	0.225	0.27	0.315	0.36
91–115	0.03	0.06	0.09	0.12	0.15	0.18	0.21	0.24
116–140	0.027	0.055	0.082	0.11	0.137	0.164	0.191	0.22
141–165	0.023	0.045	0.067	0.09	0.113	0.135	0.158	0.18
166–190	0.02	0.04	0.06	0.08	0.10	0.12	0.14	0.16
191–215	0.015	0.03	0.045	0.06	0.075	0.09	0.105	0.12

*Drinking time one hour

How does time affect BAC?

If a person takes 4 drinks in one hour, the BAC will be higher than it would be if the person took the same number of drinks over 2 hours. As an adult drinks, the liver removes alcohol at a fairly constant rate of about 17.5 mL per hour. That is the amount of alcohol in 1 standard drink. At the end of a 2-hour period the amount of alcohol in 2 of the drinks will have been converted to water and carbon dioxide by the liver.

How do people with different BACs react?

Table 5.6.15A-3 summarizes some common mental and physical behaviors related to the BAC of drinkers.

Name ________________________________

Table 5.6.15A-3 Common mental and physical behaviors related to BAC

Blood Alcohol Concentration (BAC)	**Mental and Physical Behaviors**
0.05%	Drinker's powers of judgment, thinking, and self-control are reduced; there is often a relaxed feeling.
0.10%	Drinker appears clumsy, visual reaction time is slowed, and speech is slurred. This is the legal limit for driving a car in many states.
0.20%	Drinker staggers, often angers easily, may shout or weep; brain centers controlling muscles work poorly
0.30%	Drinker acts in a dazed or confused way, often falls asleep.
0.40%	Drinker goes into an unconscious state called a coma. Death may occur.
0.50%	Drinker dies unless immediate medical aid is received.

DASH

Name ______________________

Date ______________________

STUDENT PAGE 5.6.15B INTOXICATION

1. Record the volume of water that was added to dilute each 17.5 mL (0.6 oz) of simulated alcohol in the drinks shown in the table below.

Container and simulated drink	Total volume of drink	Volume of simulated alcohol in drink	Volume of diluting water added
Shot glass of 80-proof whiskey, vodka, or gin	43.5 mL (1.5 oz)	17.5 mL (0.6 oz)	____________
Cocktail glass of mixed drink	87.0 mL (3.0 oz)	17.5 mL (0.6 oz)	____________
Glass of wine	145.0 mL (5.0 oz)	17.5 mL (0.6 oz)	____________
Can or bottle of beer	348.0 mL (12.0 oz)	17.5 mL (0.6 oz)	____________

2. Explain how you found the volume of diluting water to add.

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Name ______________________

3. Use the information in Table SP 5.6.15A-2 to calculate the approximate number of drinks a person of your weight would have to take in 1 hour to reach the BACs shown in the table below.

Weight:	**Blood Alcohol Concentration (BAC)**				
................lb	**0.05%**	**0.10%**	**0.20%**	**0.30%**	**0.40%**
Number of drinks taken in 1 hour					

DASH

Name________________________

Date_________________________

STUDENT PAGE 5.6.16 DRUG LAWS

QUESTIONS ABOUT DRUGS

What are drugs?
Drugs are chemical substances other than nutrients (foods, vitamins, minerals, and water). When taken into our body, they help fight disease or change the way our body works. Drugs include such substances as aspirin, penicillin, and cough syrups as well as more commonly abused drugs.

What is drug abuse?
Drug abuse refers to use of a drug for a purpose different from the one intended by doctors or hospitals who would prescribe it. Abuse may result in dependency where one craves the drug.

What is drug addiction?
Drug addiction or drug dependency occurs when after using a drug a person develops a craving or desire and need for it. When drug-dependent persons try to stop using the drug, they can suffer psychologically and physically, often becoming ill.

What kinds of drugs are abused?
The main drugs that are abused are classified as *narcotics, stimulants, depressants, hallucinogens*, and *cannabis*. Most of the drugs that are abused are also used for medical purposes.

What are narcotic drugs?
Narcotics are painkillers, also called *analgesics*. Originally the term "narcotics" referred to drugs derived from opium.

What is opium?
Opium is a mixture of drugs that come from a fluid produced by the poppy *Papaver somniferum.* Raw opium contains two major narcotics or painkillers, *morphine* and *codeine*. Other drugs are also made by altering

Name ______________________

the chemical structure of the natural compounds in opium. A common manufactured drug is *heroin,* which is made from morphine.

What are synthetic narcotics?
Synthetic narcotics are compounds that are painkillers but are not derived from opium. These include *methadone*.

What are depressants?
Depressants, or *sedatives,* are used to calm the nerves and bring sleep. They are commonly called "downers." Depressants include alcohol and Valium.

What are stimulants?
Stimulants are drugs that give a feeling of strength and alertness. They are commonly called "uppers." These include *caffeine, cocaine, crack,* and *amphetamines.*

What are hallucinogens?
Hallucinogens are drugs that produce distortions of reality. Often terrifying, misshapen figures and objects appear along with wild displays of color. Two common hallucinogenic drugs are *LSD* and *PCP*.

What is cannabis?
Cannabis is any drug extracted from the hemp plant (*Cannabis sativa*). These drugs produce a sense of calm and relaxation. The most common cannabis drugs are *marijuana* and *hashish.*

What is the history of drug legislation in the United States?
The damaging effect of various drugs has been recognized by the U.S. Congress since early in this century. In 1914 Congress passed the Harrison Narcotic Act, which established federal control of heroin. Manufacture, sale, and transportation of drinking alcohol within the United States was prohibited by the 18th or Liquor Prohibition Amendment to the U.S. Constitution. This amendment was ratified by the states in 1919 but was repealed in 1933 by the 21st Amendment. Marijuana came under federal control in 1937. Since then there has been additional state and federal legislation to regulate the use of drugs.

What is the Controlled Substance Act?
In 1970 the U.S. Congress passed the Controlled Substance Act (CSA). This act established the criteria for classifying how drugs can be legally dispensed.

Name ____________________

How do federal agencies determine whether a drug should be controlled?

The following questions are asked when the status of a drug is determined:

- What is the potential for abuse of the drug?
- What do we know about how the drug works in the body?
- What other scientific knowledge do we have about the drug?
- What is the history and what are the present patterns of the drug's abuse?
- How significant are the effects of the drug's abuse?
- What are the risks to public health when the drug is used?
- What is the probability of drug dependency?
- Can other controlled drugs be easily made from the drug?

How does the Federal Drug Enforcement Administration control drugs?

Drugs are controlled by regulating their distribution by drugstores, hospitals, and doctors. Drugstores, hospitals, and doctors are made responsible for seeing that drugs are given only to persons who have a medical need for them. The way drugs are regulated depends on how they are classified in the Federal Drug Schedule.

What is the Federal Drug Schedule?

The federal government has classified drugs according to their potential for abuse. The federal classification fits drugs within one of five schedules. The most potentially dangerous drugs are in Schedule I, the least dangerous in Schedule V.

What are SCHEDULE I drugs?

Drugs that come under SCHEDULE I classification have some or all of the following characteristics:

- They have no acceptable medical use in the United States now.
- There is no safe way to supervise their use.
- There is great danger for abuse, including high potential for physical and psychological dependency.
- They are used for research only.

Examples are heroin, LSD, and marijuana.

What are SCHEDULE II drugs?

Drugs that come under SCHEDULE II classification have the following characteristics:

- They have acceptable medical use.
- Their use can be safely supervised.

Name ____________________

- There is great danger from abuse, including high potential for physical and psychological dependency.
- A doctor's prescription is required with no refills. Prescriptions for resupply must be made separately.

Examples are cocaine and amphetamines.

What are SCHEDULE III drugs?

Drugs that come under SCHEDULE III classification have the following characteristics:

- They have acceptable medical use.
- Their use can be safely supervised.
- There is danger from abuse, including moderate potential for physical dependency and high potential for psychological dependency.
- A doctor's prescription is required with refills allowed.

Examples are glutethimide and tetrahydrocannibinol.

What are SCHEDULE IV drugs?

Drugs that come under SCHEDULE IV classification have the following characteristics:

- They have acceptable medical use.
- Their use can be safely supervised.
- There is a danger from abuse, including low potential for physical dependency but high potential for psychological dependency.
- A doctor's prescription is required with refills allowed.

Examples are Librium and Valium.

What are SCHEDULE V drugs?

Drugs that come under SCHEDULE V classification have the following characteristics:

- They have acceptable medical use.
- Their use can be safely supervised.
- There is a danger from abuse including low levels of both physical and psychological dependency.
- A doctor's prescription is required with refills allowed.

Examples are Darvon and Tylenol with codeine.

Controlled Substances - Uses & Effects

DRUGS/CSA SCHEDULES		TRADE OR OTHER NAMES	MEDICAL USES	DEPENDENCE		TOLERANCE	DURATION (Hours)	USUAL METHODS OF ADMINISTRATION	POSSIBLE EFFECTS	EFFECTS OF OVERDOSE	WITHDRAWAL SYNDROME
				Physical	Psychological						
NARCOTICS											
Opium	II III IV	Dover's Powder, Paregoric, Parepectolin	Analgesic, Antidiarrheal	High	High	Yes	3-6	Oral, smoked	Euphoria, drowsiness, respiratory depression, constricted pupils, nausea	Slow and shallow breathing, clammy skin convulsions, coma, possible death	Watery eyes, runny nose, yawning, loss of appetite, irritability, tremors, panic cramps, nausea chills and sweating
Morphine	II III	Morphine, MS-Contin, Roxanol, Roxanol-SR	Analgesic, Antitussive	High	High	Yes	3-6	Oral, smoked, injected			
Codeine	II III V	Tylenol w/Codeine, Empirin w/Codeine Robitussan A-C, Fiorinal w/Codeine	Analgesic, Antitussive	Moderate	Moderate	Yes	3-6	Oral, injected			
Heroin	I	Diacetylmorphine, Horse, Smack	None	High	High	Yes	3-6	Injected, sniffed, smoked			
Hydromorphone	II	Dilaudid	Analgesic	High	High	Yes	3-6	Oral, injected			
Meperidine(Pethidine)	II	Demerol, Mepergan	Analgesic	High	High	Yes	3-6	Oral, injected			
Methadone	II	Dolophine, Methadone, Methadose	Analgesic	High	High-Low	Yes	12-24	Oral, injected			
Other Narcotics	I II III IV V	Numorphan, Percodan, Percocet, Tylox Tussionex, Fentanyl, Darvon, Lomotil, Talwin	Analgesic, antidiarrheal, antitussive	High-Low	High-Low	Yes	Variable	Oral, injected			
DEPRESSANTS											
Chloral Hydrate	IV	Noctec	Hypnotic	Moderate	Moderate	Yes	5-8	Oral	Slurred speech, disorientation, drunken behavior without the odor of alcohol	Shallow respiration, clammy skin, dilated pupils, weak and rapid pulse, coma, possible death	Anxiety, insomnia, tremors, delirium, convulsions, possible death
Barbiturates	II III IV	Amytal, Butisol, Fiorinal, Lotusate, Nembutal, Seconal, Tuinal, Phenobarbital	Anasthetic, Anticonvulsant, sedative, hypnotic, veterinary euthanasia agent	High-Mod	High-Mod	Yes	1-16	Oral			
Benzodiazepines	IV	Ativan, Dalmane, Diazepam, Librium, Xanax, Serax, Valium, Tranxexe, Verstran, Versed, Halcion, Paxipam, Restoril	Antianxiety, anti-convulsant, sedative, hypnotic	Low	Low	Yes	4-8	Oral			
Methaqualone	I	Quaalude	Sedative, hypnotic	High	High	Yes	4-8	Oral			
Glutethimide	III	Doriden	Sedative, hypnotic	High	Moderate	Yes	4-8	Oral			
Other Depressants	III IV	Equanil, Miltown, Noludar, Placidyl, Valmid	Antianxiety, sedative, hypnotic	Moderate	Moderate	Yes	4-8	Oral			
STIMULANTS											
Cocaine	II	Coke, Flake, Snow, Crack	Local anesthetic	Possible	High	Yes	1-2	Sniffed, smoked, injected	Increased alertness, excitation, euphoria, increased pulse rate & blood pressure, insomnia, loss of appetite	Agitation, increase in body temperature, hallucinations, convulsions, possible death	Apathy, long periods of sleep, irritability depression, disorientation
Amphetamines	II	Biphetamine, Delcobese, Desoxyn, Dexedrine, Obetrol	Attention deficit disorders, narcolepsy, weight control	Possible	High	Yes	2-4	Oral, injected			
Phenmetrazine	II	Preludin	Weight control	Possible	High	Yes	2-4	Oral, injected			
Methylphenidate	II	Ritalin	Attention deficit disorders, narcolepsy	Possible	High	Yes	2-4	Oral, injected			
Other Stimulants	III IV	Adipex, Cylert, Didrex, Ionamin, Melfiat, Plegine, Sanorex, Tenuate, Tepanil, Prelu-2	Weight control	Possible	High	Yes	2-4	Oral, injected			
HALLUCINOGENS											
LSD	I	Acid, Microdot	None	None	Unknown	Yes	8-12	Oral	Illusions and hallucinations, poor perception of time and distance	Longer, more intense "trip" episodes, psychosis, possible death	Withdrawal syndrome not reported
Mescaline and Peyote	I	Mexc, Buttons, Cactus	None	None	Unknown	Yes	8-12	Oral			
Amphetamine Variants	I	2 5-DMA, PMA, STP, MDA, MDMA, TMA, DOM, DOB	None	Unknown	Unknown	Yes	Variable	Oral, injected			
Phencyclidine	II	PCP, Angel Dust, Hog	None	Unknown	High	Yes	Days	Smoked, oral, injected			
Phencyclidine Analogues	I	PCE, PCPy, TCP	None	Unknown	High	Yes	Days	Smoked, oral, injected			
Other Hallucinogens	I	Bufotenine, Ibogaine, DMT, DET, Psilocybin Psilocyn	None	None	Unknown	Possible	Variable	Smoked, oral, injected			
CANNABIS											
Marijuana	I	Pot, Acapulco Gold, Grass, Reefer, Sinsemilla, Thai Sticks	None	Unknown	Moderate	Yes	2-4	Smoked, oral	Euphoria, relaxed inhibitions, increased appetite, disoriented behavior	Fatigue, paranoia, possible psychosis	Insomnia, hyperactivity, and decreased appetite occasionally reported
Tetrahydrocannabinol	I II	THC, Marinol	Cancer chemotherapy, antinauseant	Unknown	Moderate	Yes	2-4	Smoked, oral			
Hashish	I	Hash	None	Unknown	Moderate	Yes	2-4	Smoked, oral			
Hashish Oil	I	Hash Oil	None	Unknown	Moderate	Yes	2-4	Smoked, oral			

Source: U.S. Drug Enforcement Adm.

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GRADE FIVE
CLUSTER 7

Wayfinding and Transportation

5.7.1 Where in the World Are We?
5.7.2 Planetarium
5.7.3 Mapping the Sky
5.7.4 The North Pole, Equator, and Ecliptic
5.7.5 Where Is Earth?

ACTIVITY 5.7.1
WHERE IN THE WORLD ARE WE?

OBJECTIVES

The students
- Discuss common ways of describing where people live.
- Find ways to locate places on city maps.
- Find ways of describing locations on globes and world maps.
- Develop working definitions of latitude and longitude.
- Develop working definitions of prime meridian, equator, international date line, and celestial poles.

BACKGROUND

This activity is the first of four activities about locating objects in space. Here the students use the grid systems of maps and globes to find locations and define latitude and longitude. The activity should be followed by Activities 5.7.3 MAPPING THE SKY, 5.7.4 THE NORTH POLE, EQUATOR, AND ECLIPTIC, and 5.7.5 WHERE IS EARTH?

Concept Map

A concept map of the term map opens the activity. Students' responses will give insights on things to emphasize as the activity unfolds. The students may well already have the background to use terrestrial coordinate systems. If the concept mapping reveals this, hold a quick review and move on to Activity 5.7.2 PLANETARIUM.

Location Game

In WHERE IN THE WORLD ARE WE? the students progress systematically from describing the location of their homes to using the grid system found on city maps to finding latitude and longitude on maps and globes. At the end of this section the students play the Where in the World Am I? Game. One student or student group locates the latitude and longitude of a city or geographical feature, and another student or group finds the site from the coordinates. Figure SP 5.7.1(1) provides a map of the United States showing degrees of latitude and longitude.

Where possible, use a local city map with its indexes for the first map activity. The students will know special places to tantalize each other. As an alternative they can use the city map shown in Figure SP 5.7.1(2).

STUDENT ROLES

Astronomer
Surveyor
Cartographer

MATERIALS

local map with indexes
flat U.S. map with coordinates in degrees of latitude and longitude
globes
protractors
Student Page 5.7.1 WHERE IN THE WORLD ARE WE?

PRODUCTS

Completed Student Pages

PROCEDURE

1. **Have the students develop a concept map about the term *map.***

   They may include such things as these:
   - a grid
   - function—to find locations
   - compass points—north, south, east, west
   - longitude
   - latitude
   - true north (celestial north)
   - magnetic north
   - declination
   - degrees
   - coordinates
   - Greenwich
   - international date line
   - equator
   - poles
   - orienting

2. **Help the students write out directions to their home and record them on Student Page 5.7.1 WHERE IN THE WORLD ARE WE?**

   Ask such questions as these:
   - How did you direct someone to your home?
   - What are some common characteristics of the directions? (Probably most directions will give highways and streets by name; buildings by shape, size, function, street number, or name; and landmarks such as hills, towers, tunnels, and bridges.)
   - Why do we use these features? (Get at the observation that they are easy to see, easy to remember, and probably the ones we use to find our own way home.)

3. **Help the students use a city map to find special places. Give them the names of obscure places such as short streets, parks, or schools that are listed in the map's index.**

   Ask such questions as these:
   - How did you find this place? (Get at a range of ways from scanning the map to using the index.)
   - What is the quickest way of finding a place on this map? (Work to the idea of using the index.)
   - How does the index direct you to find a place? (Discuss the coordinates, usually numbers and letters.)
   - What do we mean by *coordinates?* (Develop the idea of intersection of east-west and north-south grid lines on a map.)
   - Why do we use a coordinate system? (Get at the idea that each point on a flat map can be identified with two designations—one telling us where to look up and down, one telling us where to look across. The intersection of these two points is a unique location. Have the students look up the term *coordinate* and record its definition in the Working Dictionary.)
   - Are there other places where we use coordinate systems? (Help them include such things we use them in graphing and scale drawing on grid paper.)

4. **Help the students use a map of the United States with coordinates in degrees of latitude and longitude. Have them choose a spot and write simple directions for someone else to meet them without giving the name of the place. See Figure SP 5.7.1(1). Have the students exchange papers and test their partners' systems.**

   Ask such questions as these:
   - How many found the place within half a minute? One minute or longer?
   - What characteristics made the systems easy to use?
   - Is there a coordinate system available on the map? What is it? (Lead the students to see that the top of the map is marked in degrees and the side of the map is marked in degrees.)
   - How do you distinguish the two sets of degrees? (Work to the idea that they could be called anything that describes them such as "along the top and along the side" or "east-west and north-south.")
   - What are their technical names of the two sets of degree designations? (If the students do not know them, provide the terms *degrees of longitude* along the top and *degrees of latitude* along the side.)
   - What is at 40° North (40° N) latitude and 115° West (115° W) longitude? (Denver, Colorado.)

5. **Help the students use globes to locate basic reference points.**

   Ask such questions as these:
   - Where are the poles?
   - What do we mean by *Earth's poles?* (Have the students find the dictionary definitions and put them into their Working Dictionary. Get at the idea that the *poles* are two points on a globe or model of Earth through which the imaginary axis projects into space. They are the axis of Earth's daily rotation. This idea is developed in Activity 5.2.11 MODELS OF THE SOLAR SYSTEM.)
   - What do we mean by the *equator?* (Get at the idea that on a globe or model of Earth the *equator* is a great circle halfway between the poles. Have the definition recorded in the Working Dictionary.)
   - What is the Northern Hemisphere? (Work to the definition that the *Northern Hemisphere* is the half of the world above the equator. Have the definition recorded in the Working Dictionary.)

- What do we mean by *hemisphere?* (Work to the definition of half a sphere. Have the definition recorded in the Working Dictionary.)
- Where are the *parallels of latitude?* (Get at the idea that these are circles that are parallel or equal distances from the equator. Have the definition recorded in the Working Dictionary.)
- Where is the 20° North (20° N) parallel of latitude?
- Where is the 20° South (20° S) parallel of latitude?
- What do we mean by *latitude?* (Latitude is the distance measured in degrees north or south of the equator.)
- Where do we start measuring latitude?
- Where is 0° latitude? (Help the students locate 0° at the equator.)
- Where do we stop measuring latitude? (Help the students locate 90° at the two poles.)
- Where are the *meridians of longitude?* (Have the students note that meridians of longitude are half circles running from pole to pole.)
- Where do we start measuring longitude? (Help the students locate 0° on a longitude line that runs through Greenwich, England. This is called the *prime meridian,* the first meridian.)
- Where is the 20° West (20° W) meridian of longitude?
- Where is the 20° East (20° E) meridian of longitude?
- Where do we stop measuring longitude? (Again by inspection help them find that the east and west longitude measurements end at 180° East and West.)
- What do we mean by *longitude?* (Work to the idea that *longitude* is the distance measured in degrees east or west of the prime meridian. Have the definition recorded in the Working Dictionary.)
- What do we mean by *global coordinates?* (Get at the idea that these are points of intersection of east-west and north-south measurements on a map or globe of the world. Have the definition recorded in the Working Dictionary.)

6. **Have the students separate into pairs or small groups to play the Where in the World Am I? Game.**

To play the game

- One player in a group finds the coordinates of a city or geographic feature.
- The others in the group look for that city or geographic feature.
- The players change roles.

7. **Summarize the activity with a discussion of mapping.**

Ask such questions as these:
- Why do we use a grid when we map a city?
- How is a grid drawn on maps of Earth?

EXTENSIONS

- Set up an activity center with a globe or an atlas and city maps. Provide a start-up problem card on which there is a set of coordinates. Start with the coordinates for some city on a globe or page in an atlas. When the city or area is found, provide additional coordinates for a geographic feature or a street and block number on a city map. Once a problem is solved, have the solver make a new problem card. Answers can be kept on separate cards.
- Have the students start collecting maps of faraway places.

DASH

Name____________________________

Date____________________________

STUDENT PAGE 5.7.1 WHERE IN THE WORLD ARE WE?

1. Give directions to find your home or the home of a friend.

2. Give directions for finding your home on a globe.

Name ______________________

3. Record your working definitions for the following terms:

a) latitude

____

____

b) longitude

____

____

c) coordinates

____

____

d) prime meridian

____

____

e) international date line

____

____

f) meridian

____

____

ILLUSTRATIONS

Name ______________________________

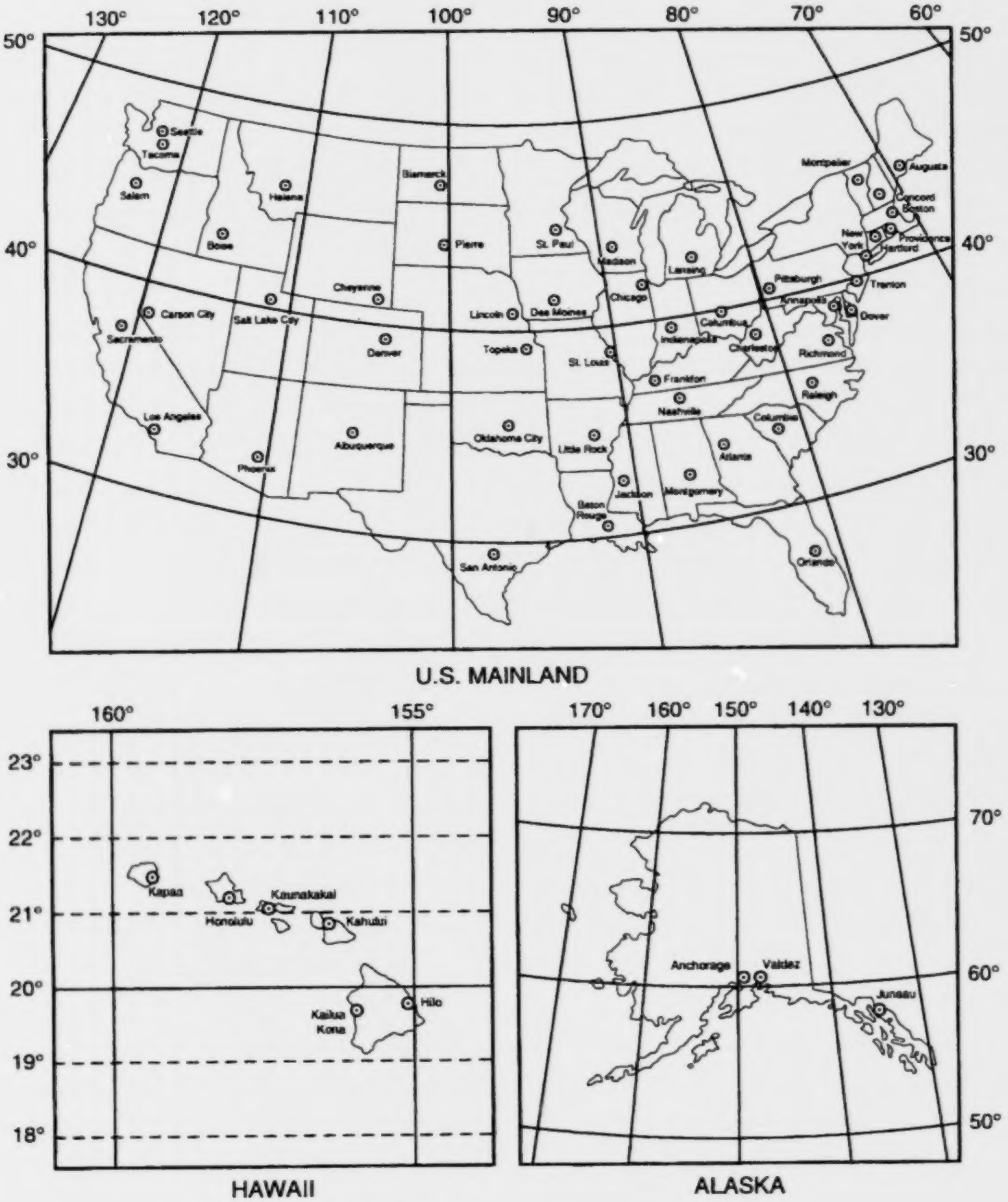
130°
120°
110°
100°
90°
80°
70°
60°
50°
40°
30°
Seattle
Tacoma
Salem
Helena
Boise
Bismarck
Pierre
St. Paul
Madison
Lansing
Montpelier
Augusta
Concord
Boston
New York
Hartford
Providence
Trenton
Pittsburgh
Annapolis
Dover
Carson City
Sacramento
Salt Lake City
Cheyenne
Denver
Lincoln
Des Moines
Chicago
Columbus
Indianapolis
Charleston
Richmond
Topeka
St. Louis
Frankfort
Nashville
Raleigh
Los Angeles
Phoenix
Albuquerque
Oklahoma City
Little Rock
Atlanta
Columbia
Jackson
Montgomery
Baton Rouge
San Antonio
Orlando
U.S. MAINLAND
160°
155°
23°
22°
21°
20°
19°
18°
Kapaa
Honolulu
Kaunakakai
Kahului
Kailua Kona
Hilo
HAWAII
170°
160°
150°
140°
130°
70°
60°
50°
Anchorage
Valdez
Juneau
ALASKA

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Figure SP 5.7.1(1) Map of the United States

Name ______________________

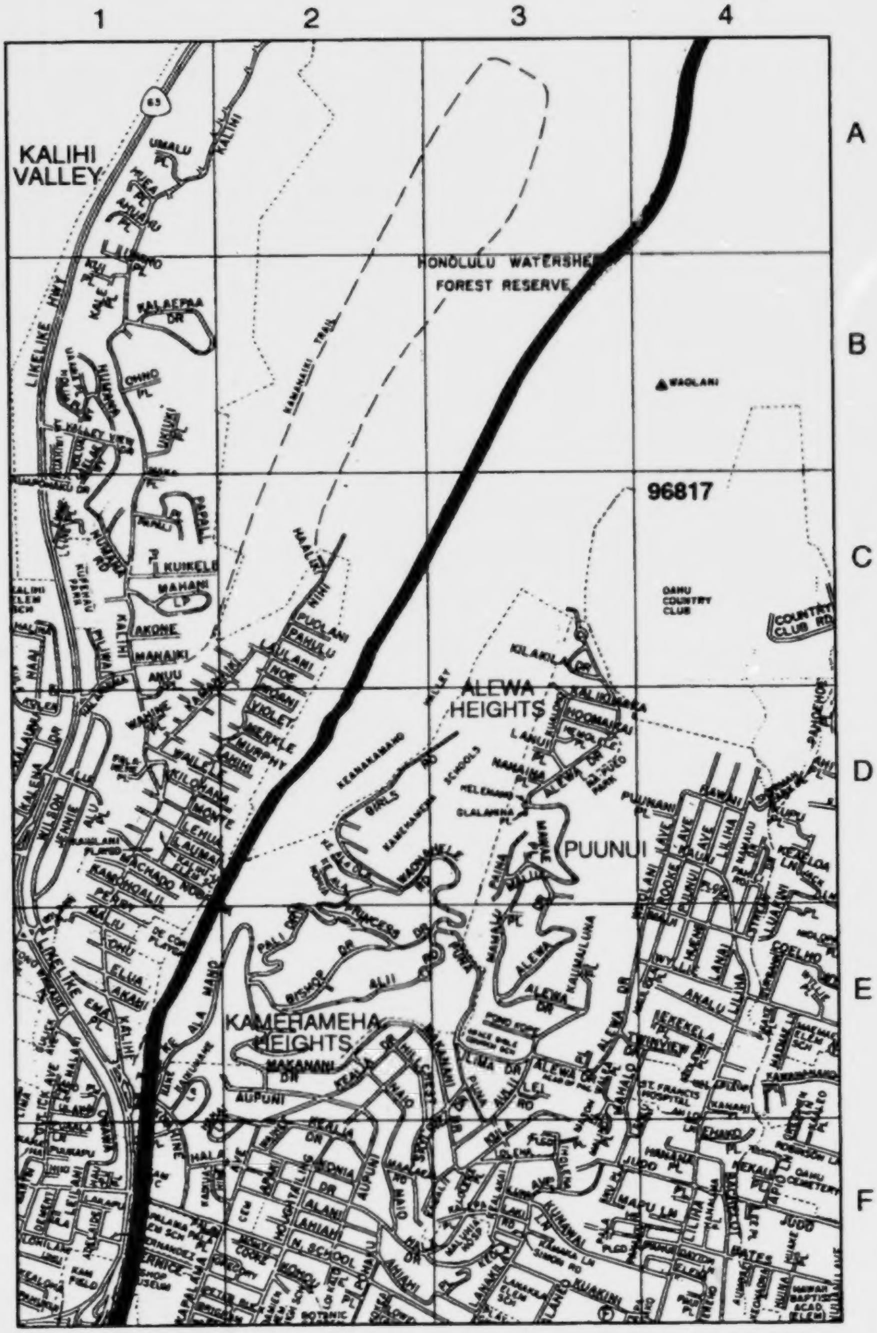
1
2
3
4
A
B
C
D
E
F
KALIHI VALLEY
HONOLULU WATERSHED FOREST RESERVE
WAOLANI
96817
OAHU COUNTRY CLUB
ALEWA HEIGHTS
PUUNUI
KAMEHAMEHA HEIGHTS
LIKELIKE HWY
KALIHI
COUNTRY CLUB RD
PALI DR
BISHOP DR
ALEWA DR
JUDD

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Figure SP 5.7.1(2) Honolulu street map

ACTIVITY 5.7.2 PLANETARIUM

OBJECTIVES

The students
- Assemble model planetariums.
- Use model planetariums to identify zodiacal constellations.

BACKGROUND

This activity is designed to give the students a tool to study major constellations, particularly those of the Zodiacal Band. It should be followed by Activity 5.7.3 MAPPING THE SKY.

DASH students have been working with Planetariums since the third grade and have used mnemonics such as the one below to recall the order of the zodiacal constellations as they are spread out across the night sky.

Capricornus, Aquarius, Pisces, Aries, Taurus, Gemini,
Cancer, Leo, Virgo, Libra, Scorpius, Sagittarius

(Your **CAP** is **AT G. C. LeViLiSS's**.)

About the middle of each month the sun advances to the next constellation in the sequence. See Student Page 5.7.2C ZODIACAL CONSTELLATIONS. For example, it enters Capricornus around January 19 and advances to Aquarius around February 15 and so forth. When the sun enters a constellation, its light blocks out the stars that make up the constellation so the constellation cannot be seen from Earth. From ancient times this "view blocking" has been described as the sun "being in the direction of" or "in" a constellation.

Declination, Right Ascension (R.A.), and the Ecliptic

The Planetariums used in Grade 5 are more sophisticated than those used in previous grades. They have declination marked in degrees from the equator to the North Pole and right ascension (R.A.) marked in hours around the equator. These are coordinate markings that will be used in our stellar wayfinding.

The students make two-sided Planetariums to be used in modeling the solar system and universe. The inside view looks out from Earth to the stars, and the outside view looks at our star system from far out in space.

STUDENT ROLE

Astronomer

MATERIALS

scissors
glue
Student Pages 5.7.2A PERSONAL PLANETARIUM
5.7.2B LARGE PLANETARIUM
5.7.2C ZODIACAL CONSTELLATIONS

PRODUCTS

Planetariums
Completed Student Pages

PROCEDURES

1. **Have the students assemble their own small personal Planetarium and work in groups to assemble a large Planetarium for class use. The students can carry their personal Planetariums home for night studies. There should be a large Planetarium for each group of 4 to 6 students.**

   Help the students
   - Glue the *IN* sheets together and then the *OUT* sheets.
   - Cut out the glued-together pieces along the dark lines.
   - Assemble the cutouts and fold and glue the Planetariums into a tent shape.
   - Slide the outside views over the inside views. Be sure the same constellations are together (one over the other) on the inside and outside of the Planetariums.

2. **Review past use of the Planetarium with the students. Have them complete Student Page 5.7.2C ZODIACAL CONSTELLATIONS.**

Help the students

- Recall their mnemonic for remembering the sequence of the constellations of the zodiac.
- Locate where they would have to be to see the view shown on the inside of the Planetariums. (Work toward agreement that they would have to be on Earth, looking up at the stars.)
- Locate where they would have to be to see the outside view. (Work toward agreement that they would have to be out in space looking down at Earth.)
- Locate stars that will be directly overhead at midnight tonight. (Locate the constellation the sun is in today on the Zodiacal Band. The stars 180° opposite that constellation are the ones that will be directly overhead tonight.)

EXTENSION

- Have the students invent a way to find the constellation that will be directly overhead at any hour of the day or night.

Name________________________

Date________________________

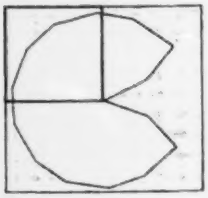
DASH

STUDENT PAGE 5.7.2A PERSONAL PLANETARIUM

Make a small model Planetarium by assembling the 4 IN and the 4 OUT sheets. The following instructions give one way to assemble the model:

- Glue together the 4 IN sheets, overlapping them to cover the "glue edge" markings.
- Cut out the glued-together pieces along the dark lines.
- Fold the IN cutout into a six-sided tent using the dashed lines radiating from Polaris as a guide. At the large opening, glue Cepheus and Lacerta so they overlap the tab opposite them.
- Close the sides of the tent by gluing the long straight edges of the V-cuts onto the tabs next to them.
- Assemble the 4 OUT sheets in the same way to make the outside view of the Planetarium.
- Slide the outside over the inside. Be sure the same constellations are together (one over the other) on the inside and outside of the Planetarium.

DASH—IN



North Celestial Pole Zodiac, R.A., Dec.

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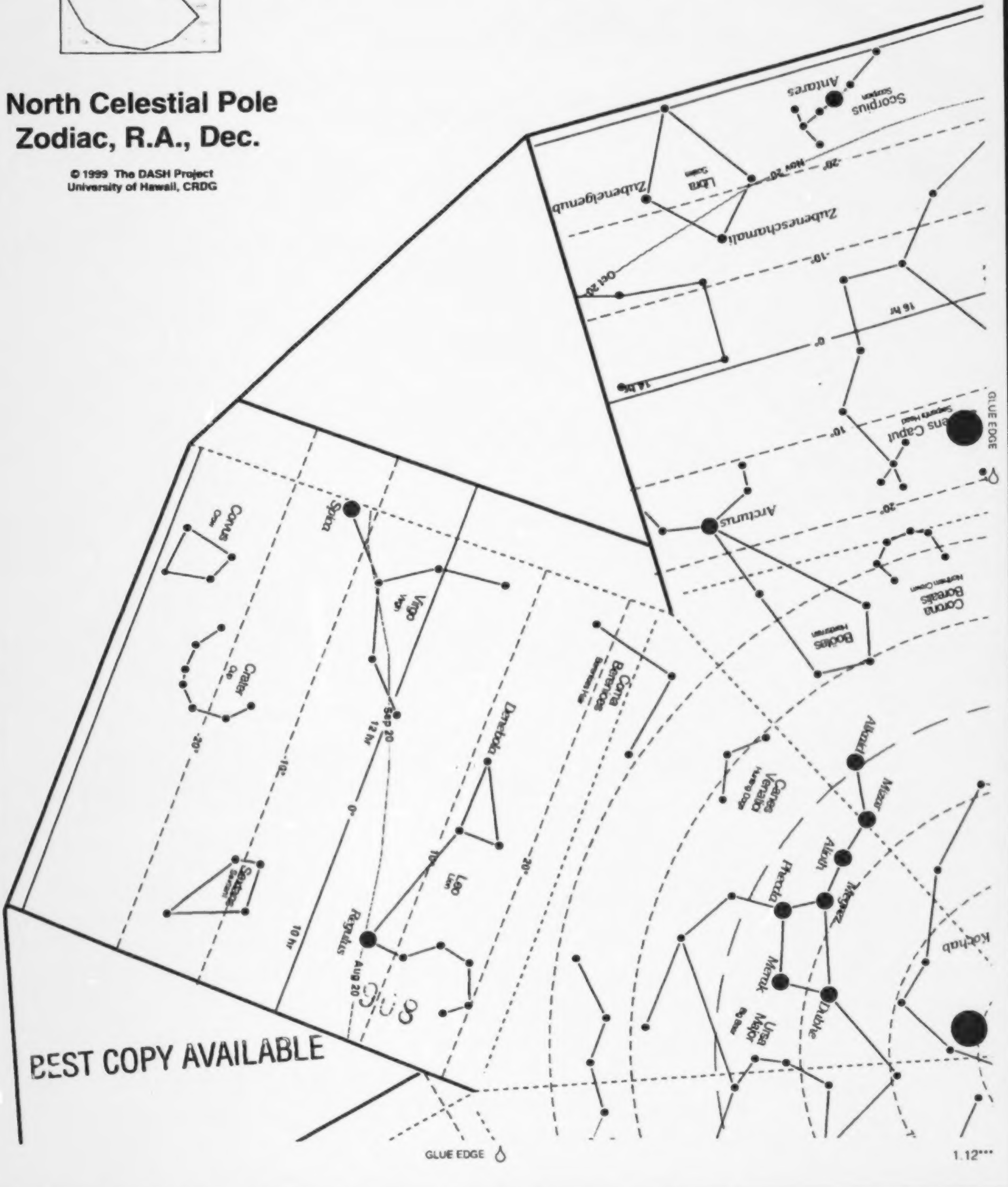
CUT ALONG INSIDE OF DOTTED LINE


Antares
Scorpius
Scorpion
Libra
Scales
Zubenelgenubi
Zubeneschamali
Nov 20
Oct 20
-20°
-10°
0°
10°
20°
16 hr
14 hr
Serpens Caput
Serpent's Head
Arcturus
Corona Borealis
Northern Crown
Boötes
Herdsman
Spica
Corvus
Crow
Virgo
Virgin
Crater
Cup
Sextans
Sextant
Sep 20
12 hr
10 hr
Regulus
Aug 20
Leo
Lion
Denebola
Coma Berenices
Berenice's Hair
Canes Venatici
Hunting Dogs
Alkaid
Mizar
Alioth
Phecda
Megrez
Merak
Dubhe
Ursa Major
Big Bear
Kochab
GLUE EDGE

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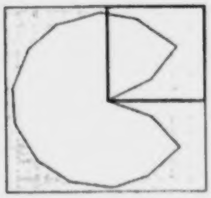
DASH—IN



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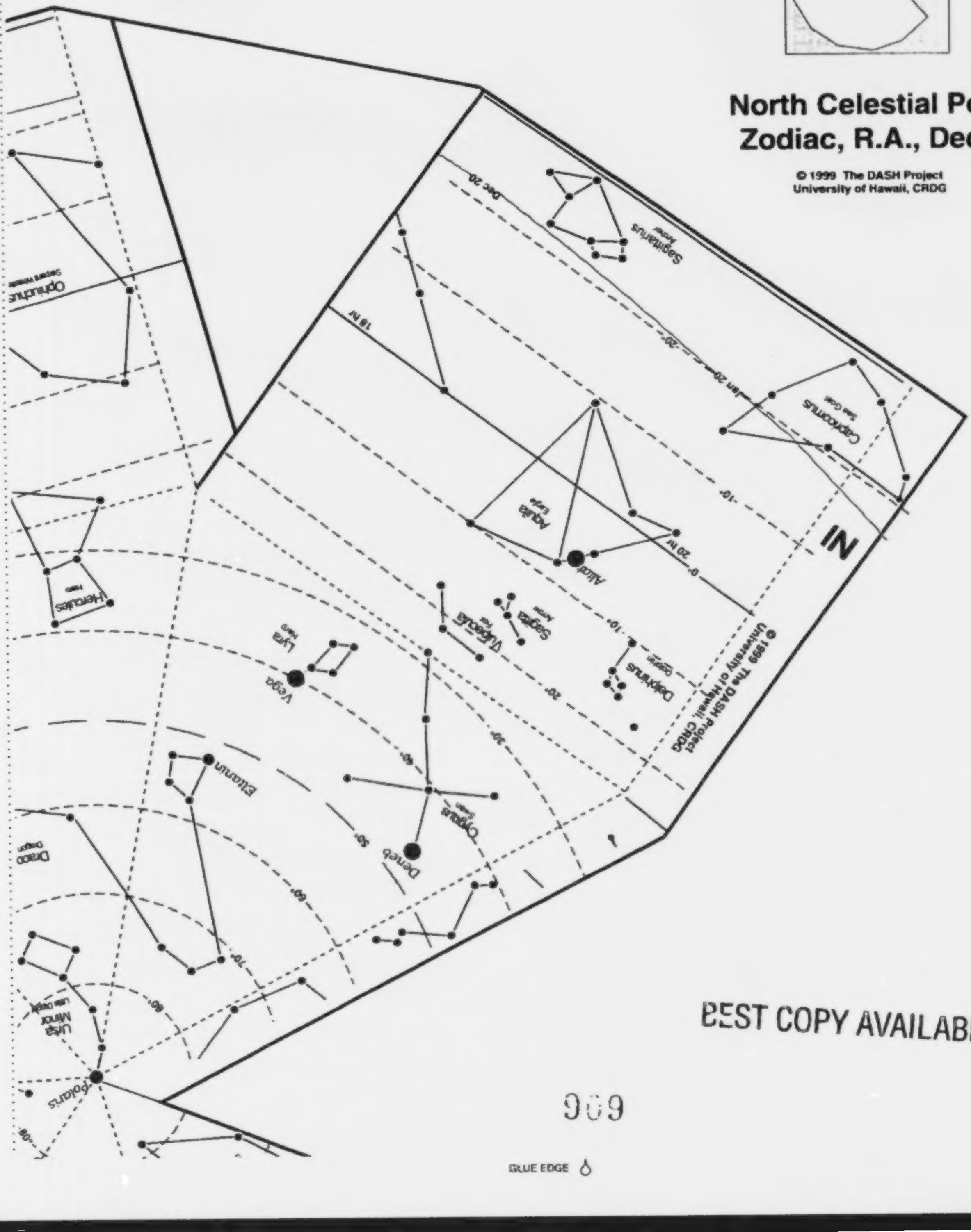
Sagittarius
Archer
Dec 20
Jan 20
18 hr
20 hr
Capricornus
Sea Goat
Aquila
Eagle
Altair
Sagitta
Arrow
Vulpecula
Fox
Delphinus
Dolphin
Lyra
Harp
Vega
Cygnus
Swan
Deneb
Eltanin
Draco
Dragon
Ursa Minor
Little Dipper
Polaris
Hercules
Hero
Ophiuchus
Serpent Wrestler
IN
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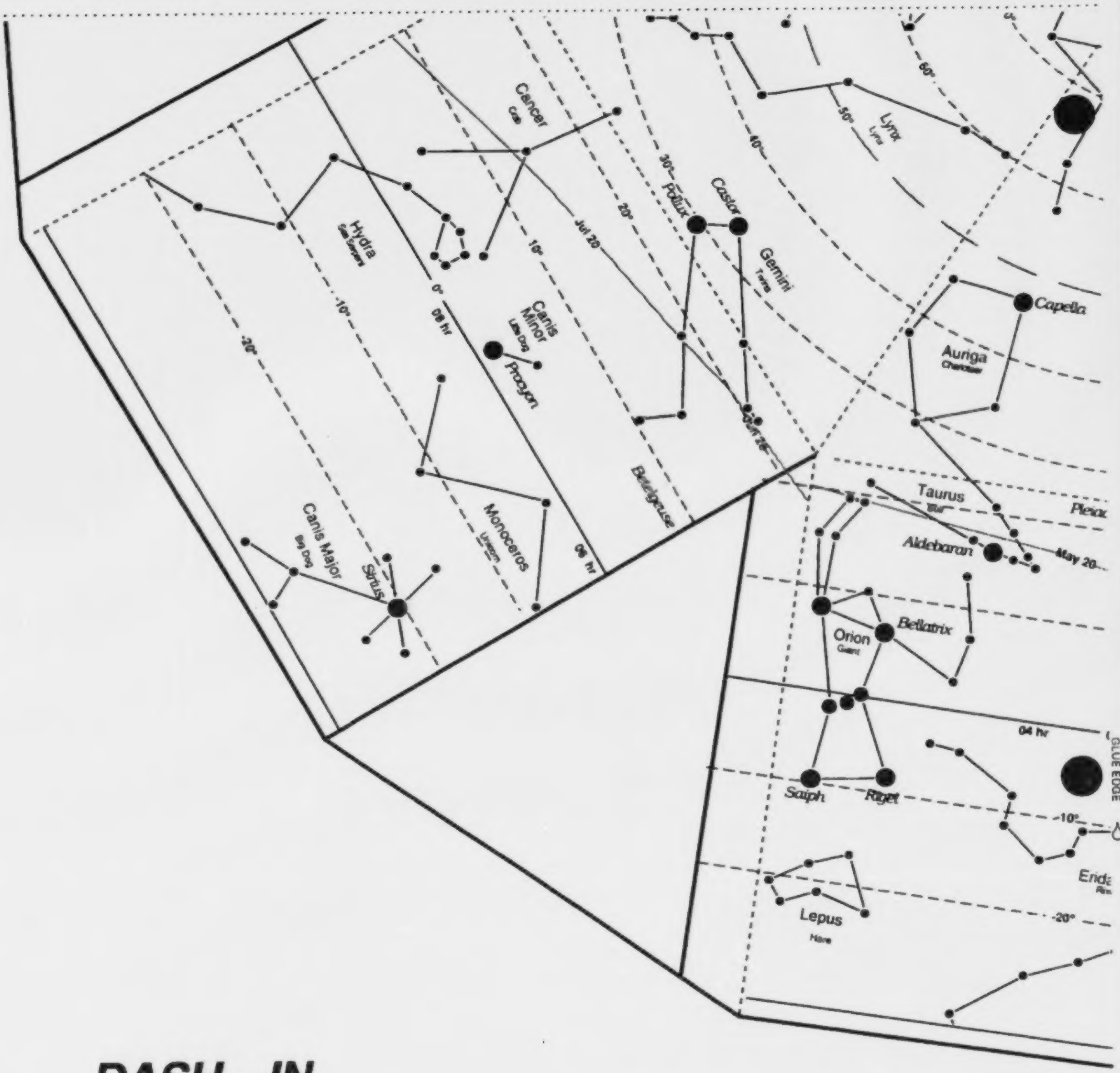
CUT ALONG INSIDE OF DOTTED LINE


Cancer
Crab
Hydra
Sea Serpent
Lynx
Lynx
60°
50°
40°
30°
20°
10°
0°
-10°
-20°
Pollux
Castor
Gemini
Twins
Jul 20
Jun 20
May 20
Canis Minor
Little Dog
Procyon
08 hr
06 hr
04 hr
Capella
Auriga
Charioteer
Betelgeuse
Taurus
Bull
Pleia
Aldebaran
Monoceros
Unicorn
Canis Major
Big Dog
Sirius
Orion
Giant
Bellatrix
Saiph
Rigel
Lepus
Hare
Erida

GLUE EDGE

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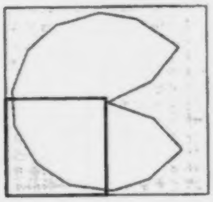

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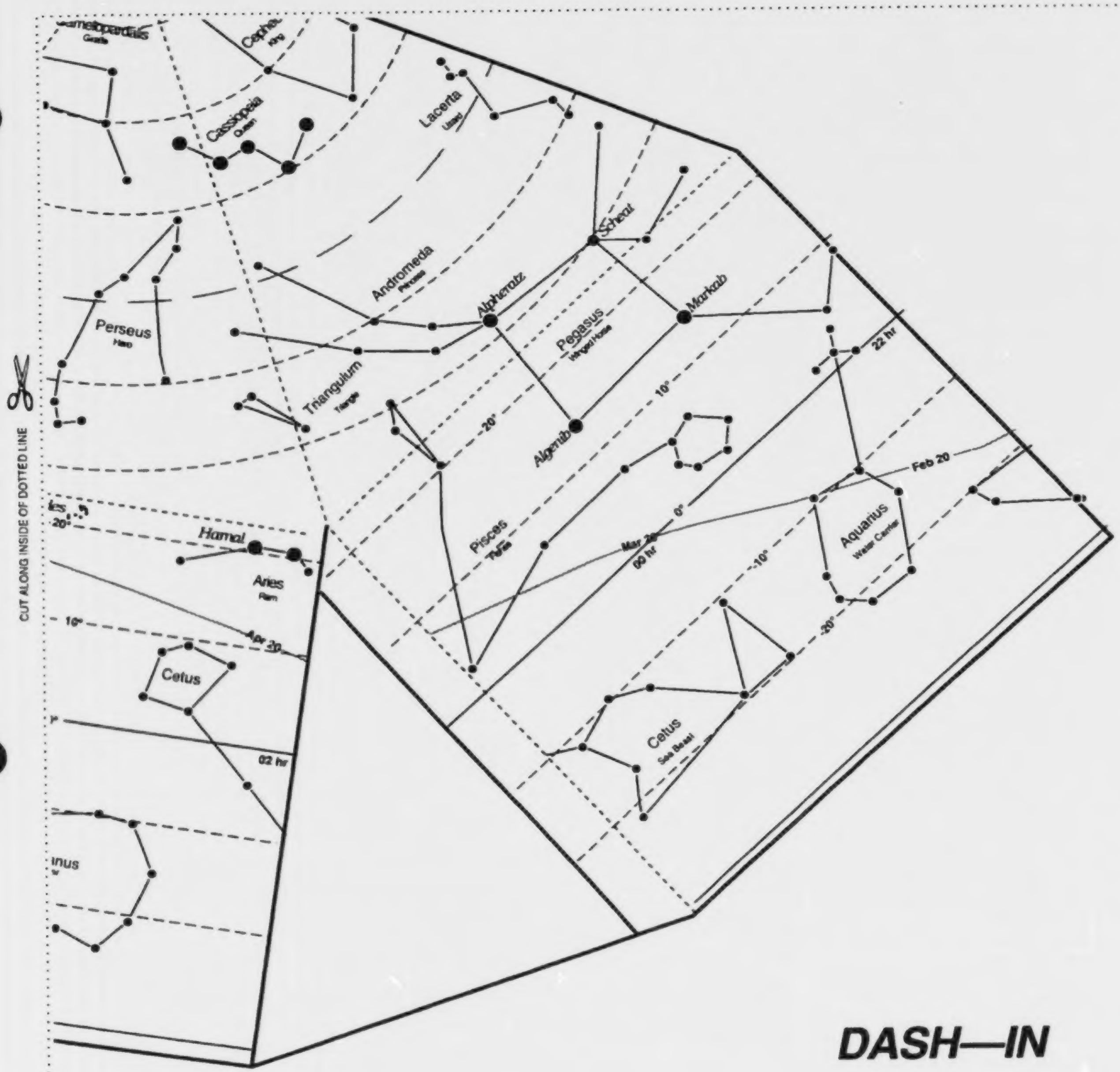
Camelopardalis
Giraffe
Cepheus
King
Cassiopeia
Queen
Lacerta
Lizard
Perseus
Hero
Andromeda
Princess
Alpheratz
Scheat
Pegasus
Winged Horse
Markab
Triangulum
Triangle
20°
10°
22 hr
Algenib
Pisces
Fishes
0°
Feb 20
Aquarius
Water Carrier
les
-20°
Hamal
Aries
Ram
Mar 20
00 hr
-10°
-20°
10°
Apr 20
Cetus
Cetus
Sea Beast
02 hr
inus

CUT ALONG INSIDE OF DOTTED LINE

GLUE EDGE

DASH—IN

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CUT ALONG INSIDE OF DOTTED LINE

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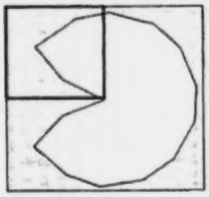

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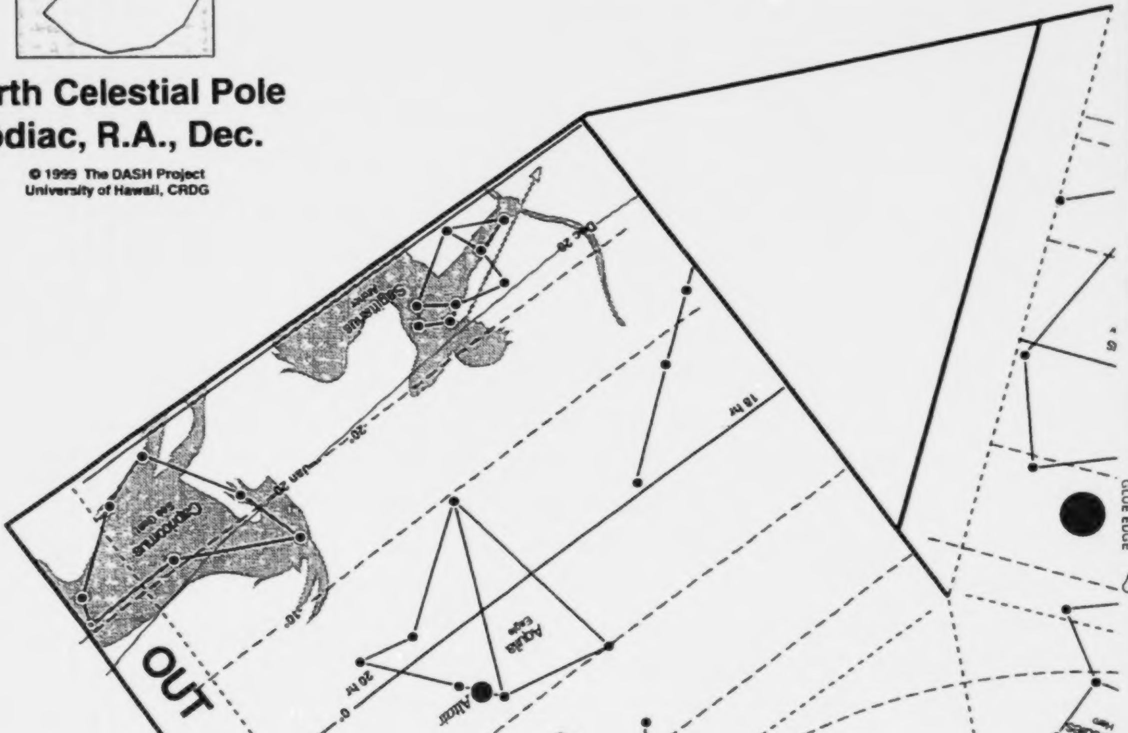
Sagittarius
Archer
Dec 20
Capricornus
Sea Goat
Jan 20
-20°
-10°
0°
18 hr
20 hr
Aquila
Eagle
Altair
OUT
10°
20°
Sagitta
Arrow
Vulpecula
Fox
Delphinus
Dolphin
Lyra
Harp
Vega
30°
40°
50°
60°
70°
80°
Eltanin
Cygnus
Swan
Deneb
Hercules
Hero
Pole
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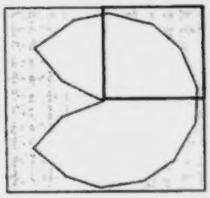

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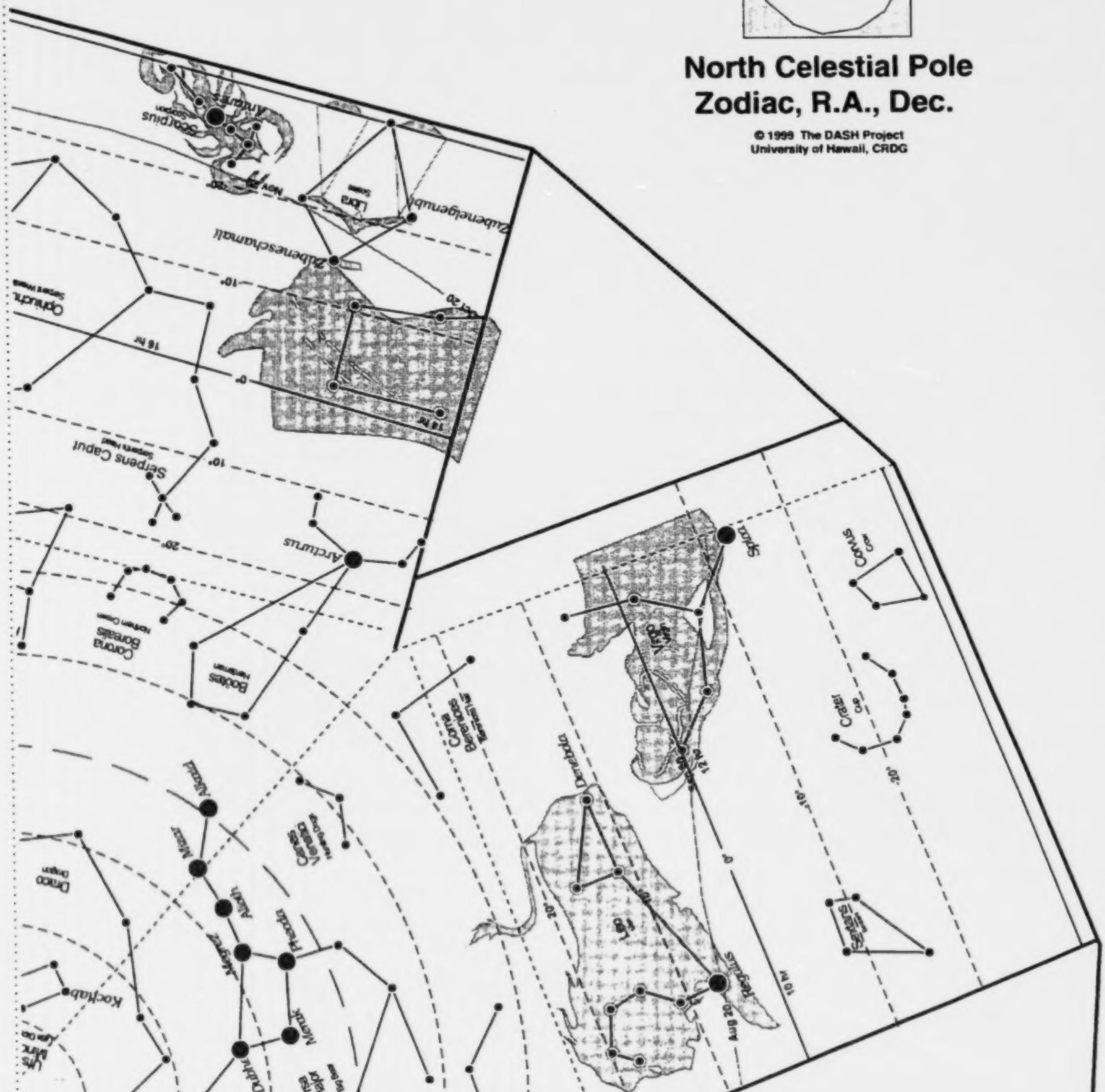
CUT ALONG INSIDE OF DOTTED LINE


Scorpius
Scorpion
Antares
Nov 20
20°
Libra
Scales
Zubenelgenubi
Zubeneschamali
10°
Ophiuchus
Serpent Holder
16 hr
0°
14 hr
Oct 20
Serpens Caput
Serpent's Head
10°
20°
Arcturus
Corona Borealis
Northern Crown
Bootes
Herdsman
Spica
Virgo
Maiden
Corvus
Crow
Crater
Cup
20°
10°
12 hr
Coma Berenices
Berenice's Hair
Denebola
0°
Leo
Lion
20°
Regulus
Aug 20
10 hr
Sextans
Sextant
Canes Venatici
Hunting Dogs
Alkaid
Mizar
Alioth
Megrez
Phecda
Dubhe
Merak
Ursa Major
Big Bear
Draco
Dragon
Kochab
Ursa Minor
Little Bear

GLUE EDGE

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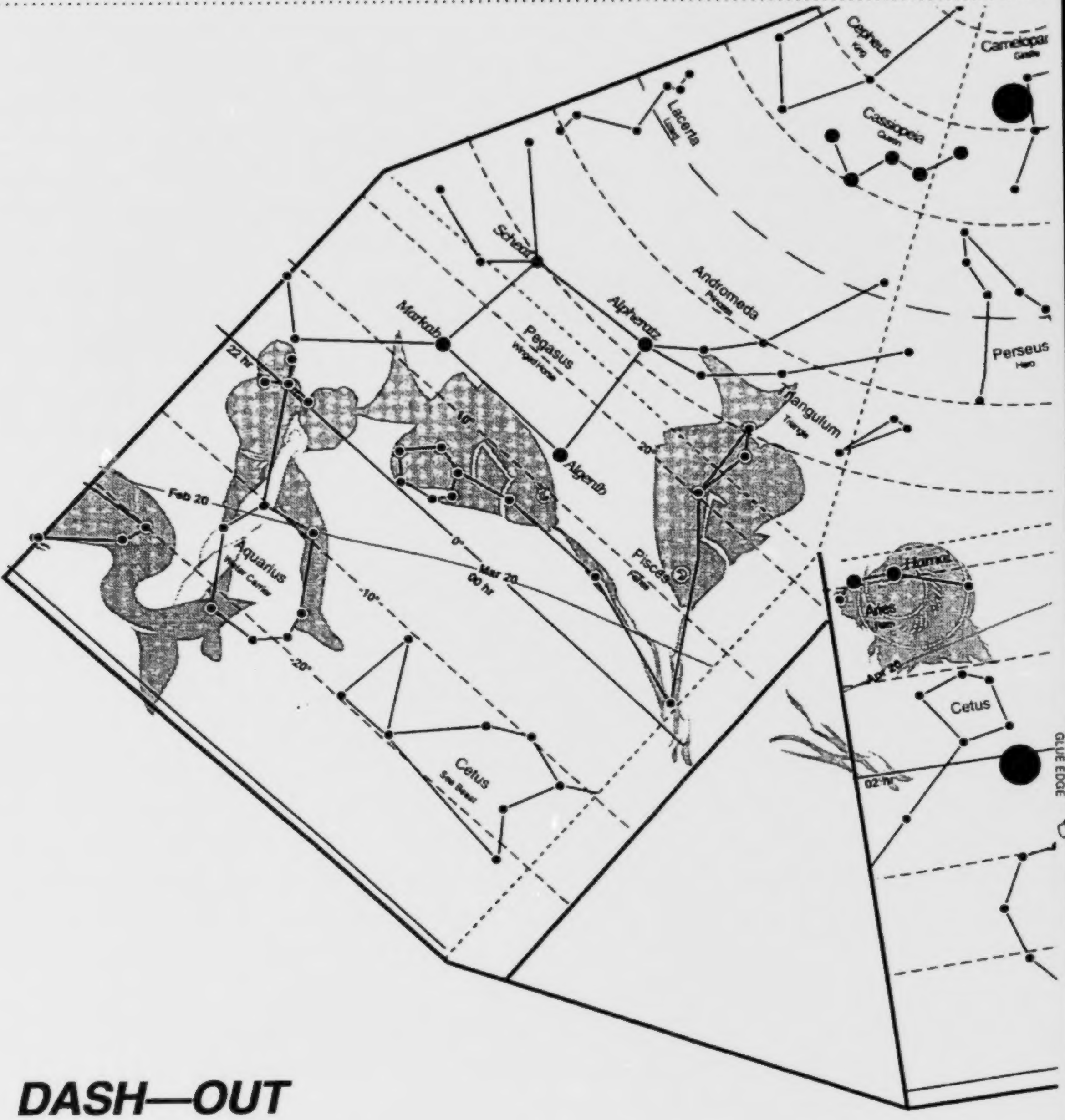
CUT ALONG INSIDE OF DOTTED LINE


Cepheus
King
Camelopar
Giraffe
Lacerta
Lizard
Cassiopeia
Queen
Scheat
Andromeda
Princess
Markab
Pegasus
Winged Horse
Alpheratz
Perseus
Hero
22 hr
Triangulum
Triangle
10°
20°
Algenib
Feb 20
0°
Mar 20
00 hr
Pisces
Fishes
Aquarius
Water Carrier
-10°
-20°
Hamal
Aries
Ram
Apr 20
Cetus
Cetus
Sea Beast
02 hr

GLUE EDGE

DASH—OUT

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Zodiac, R.A., Dec.

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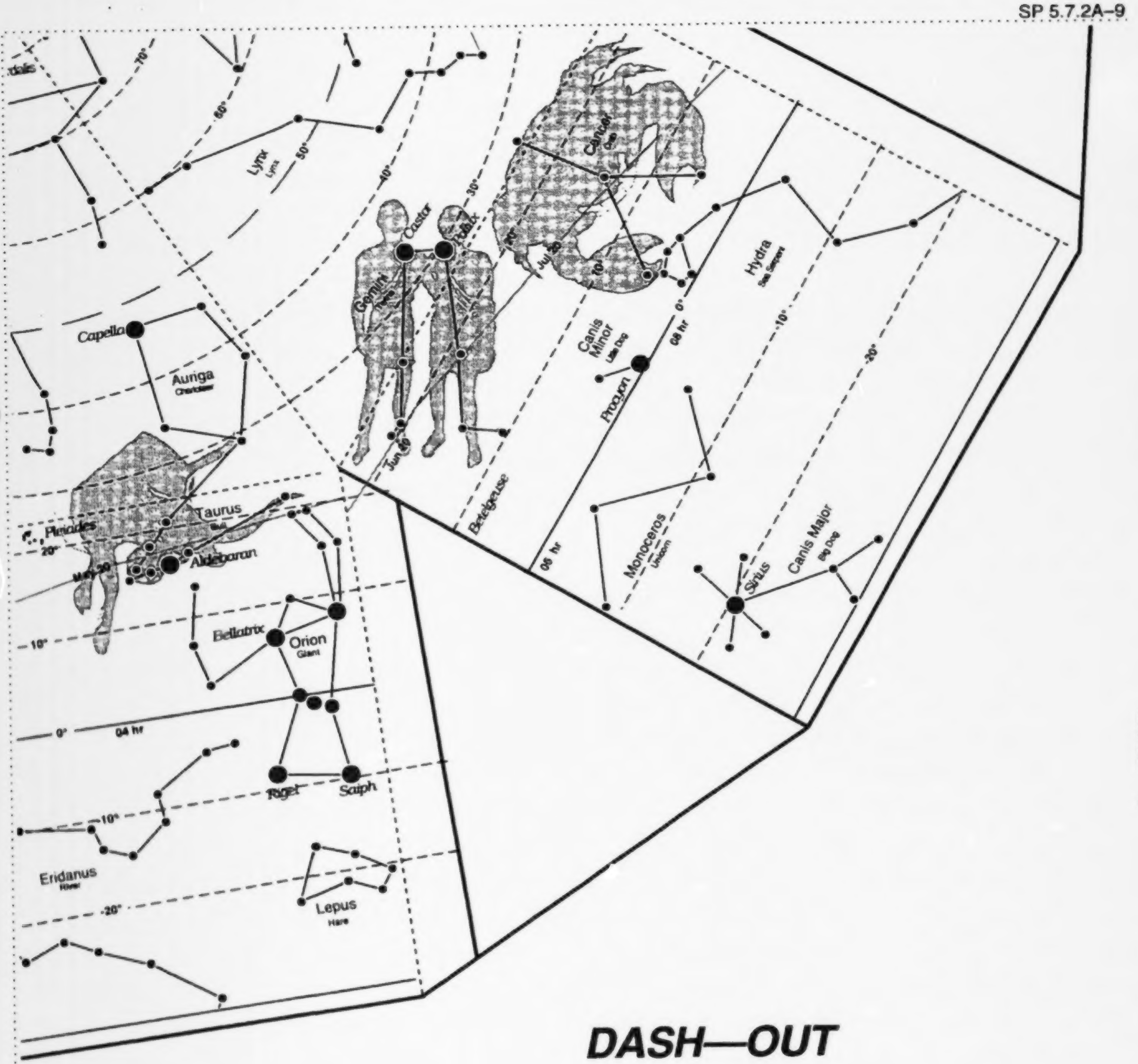
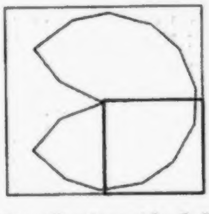

dalis
70°
60°
Lynx
Lynx
50°
40°
30°
Castor
Pollux
Gemini
Twins
Cancer
Crab
Jul 20
20°
10°
Hydra
Sea Serpent
Canis Minor
Little Dog
0°
08 hr
Procyon
-10°
-20°
Capella
Auriga
Charioteer
Jun 20
Betelgeuse
06 hr
Monoceros
Unicorn
Sirius
Canis Major
Big Dog
Taurus
Bull
Pleiades
20°
Aldebaran
May 20
10°
Bellatrix
Orion
Giant
0°
04 hr
Rigel
Saiph
-10°
Eridanus
River
-20°
Lepus
Hare

CUT ALONG INSIDE OF DOTTED LINE

GLUE EDGE

DASH—OUT



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GLUE EDGE

DASH

Name______________________

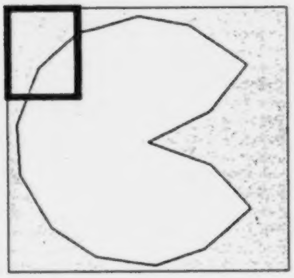
Date______________________

STUDENT PAGE 5.7.2B LARGE PLANETARIUM

Make a large model Planetarium by assembling the 12 IN and 12 OUT sheets. Use the small Planetarium as a guide. The following is one way to assemble the model:

- Glue together the 12 IN sheets, overlapping them to cover the "glue edge" markings.
- Cut out the glued-together pieces along the dark lines.
- Fold the cutout into a six-sided tent using the dashed lines radiating from Polaris as a guide. At the large open cut, glue Cepheus and Lacerta so they overlap the tab opposite them.
- Close the bottom of the tent by gluing the deep-cut straight edges of the V-cuts onto the tabs next to them.
- Assemble the 12 OUT sheets of the Planetarium the same way.
- Slide the outside over the inside. Be sure the same constellations are together (one over the other) on the inside and outside of the Planetarium.

DASH—IN



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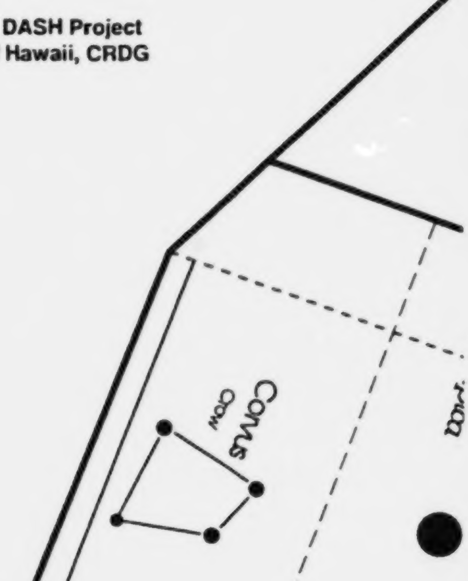
GLUE EDGE



GLUE EDGE

CUT ALONG INSIDE OF DOTTED LINE

DASH—IN

North Celestial Pole
Zodiac, R.A., Dec.

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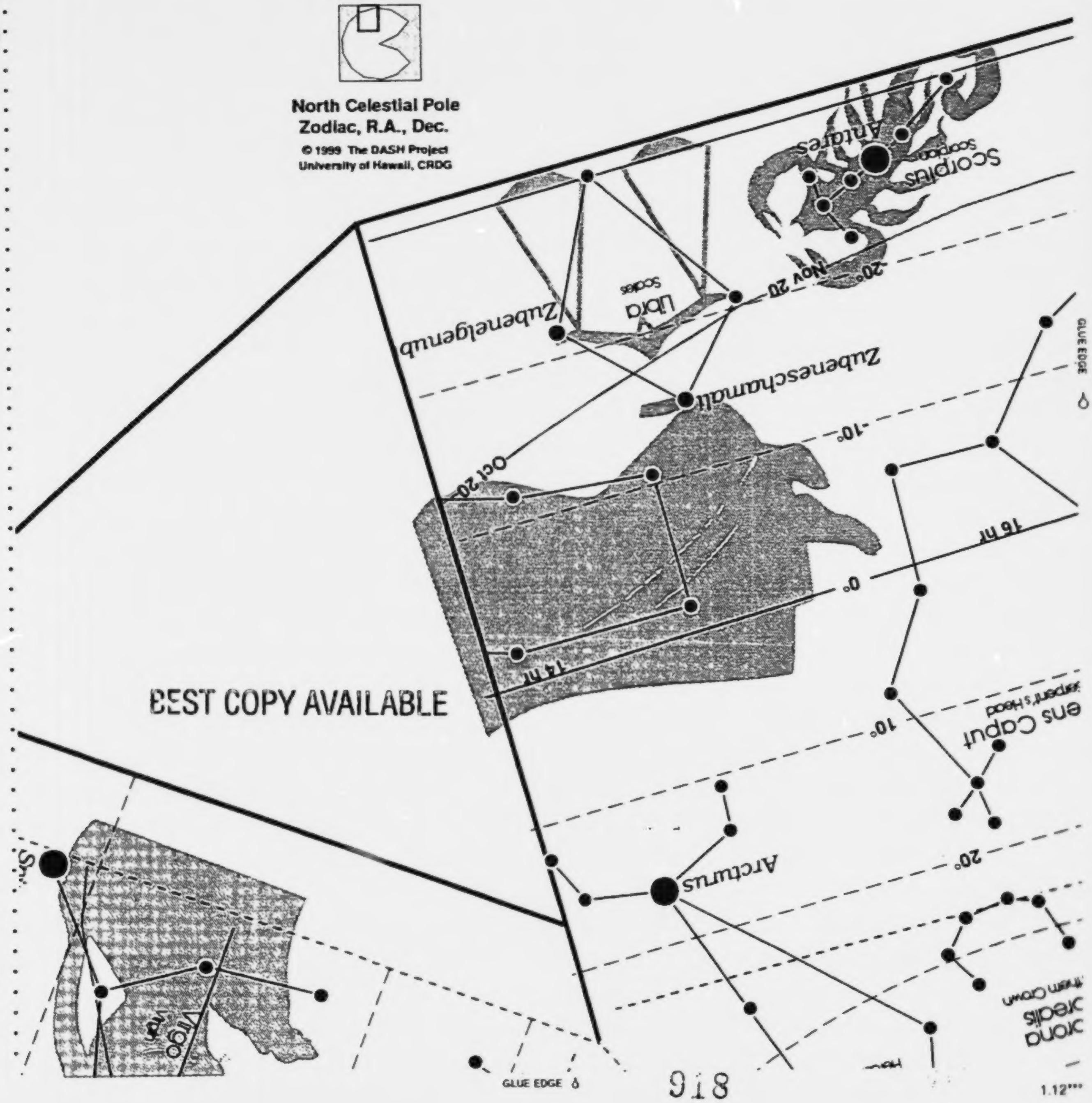
Scorpius
Scorpion
Antares
Libra
Scales
Zubenelgenubi
Zubeneschamali
Nov 20
Oct 20
-20°
-10°
0°
10°
20°
16 hr
14 hr
ens Caput
Serpent's Head
Arcturus
orona
orealis
thern Crown
Virgo
Sp
GLUE EDGE
GLUE EDGE

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DASH—IN

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Zodiac, R.A., Dec.

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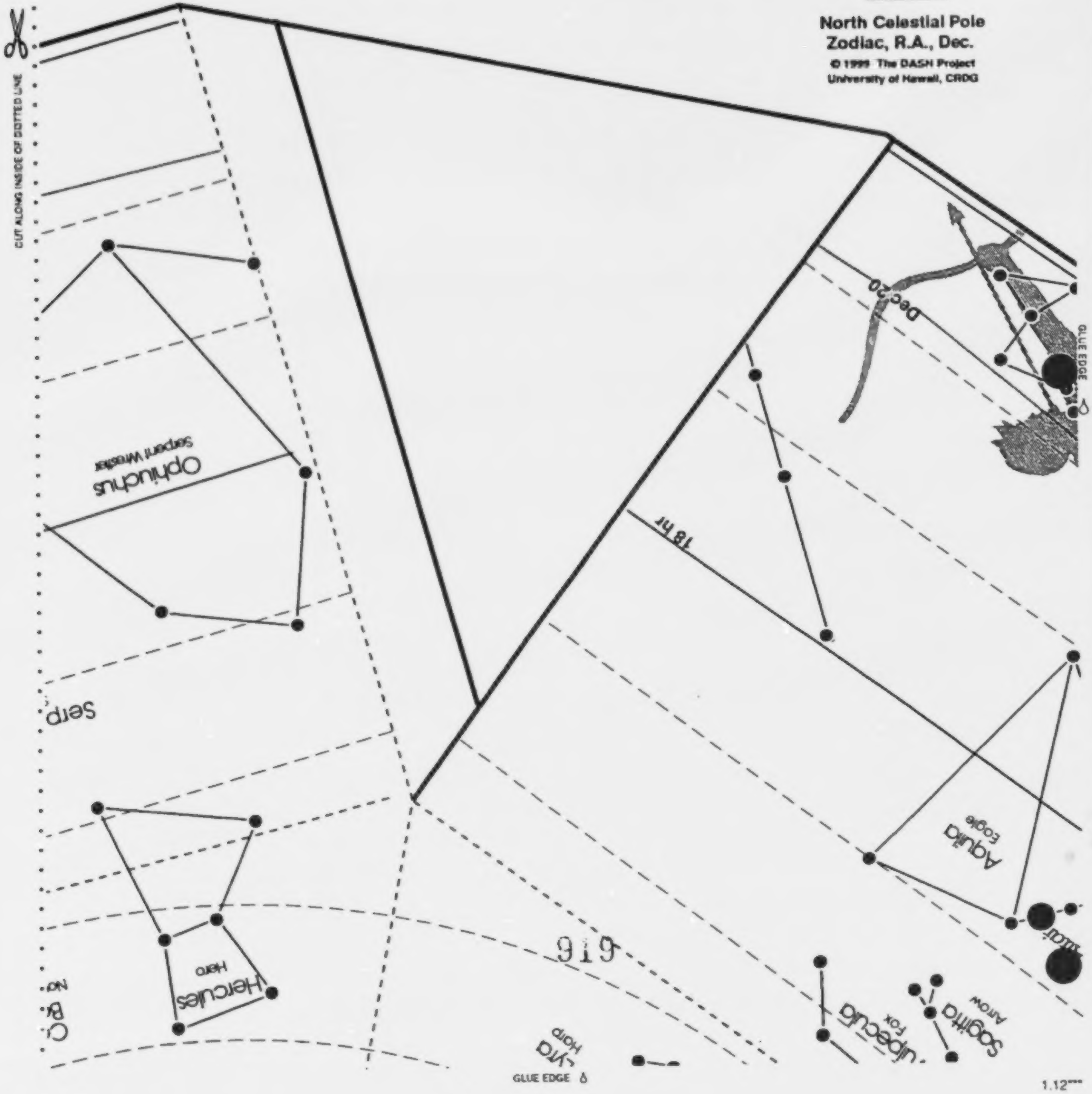
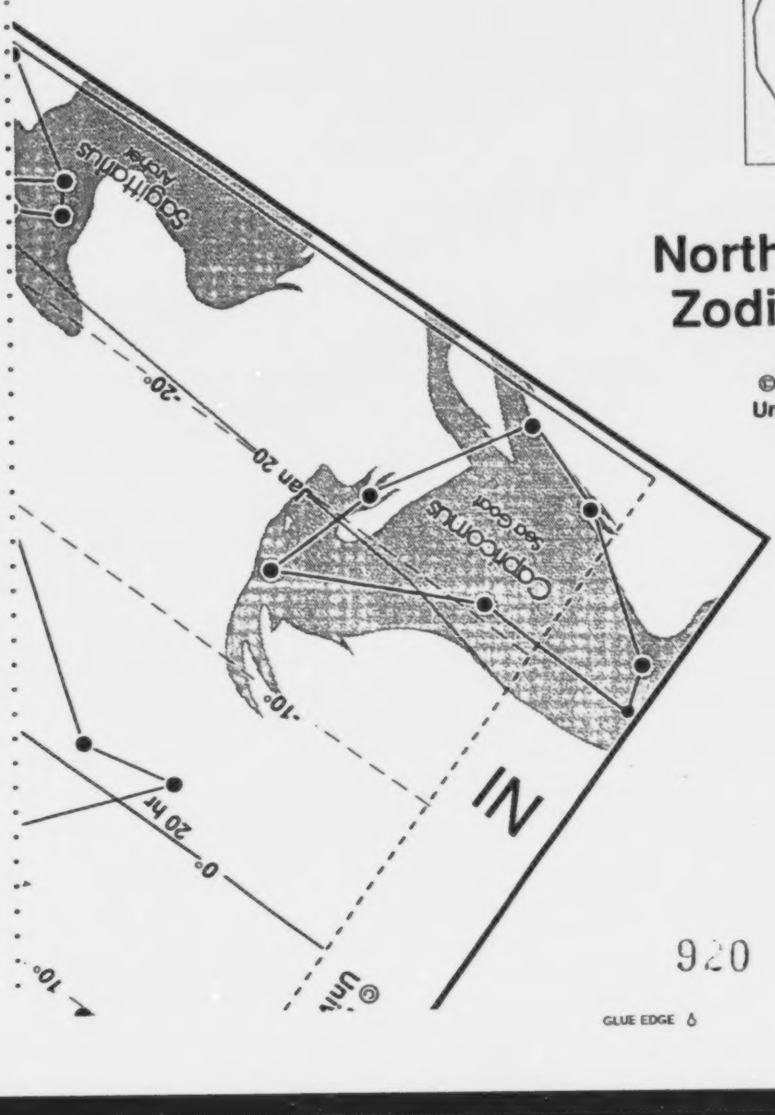
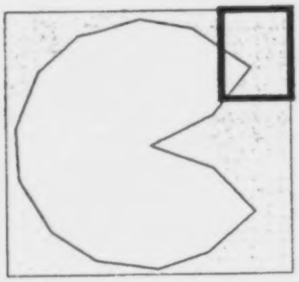

CUT ALONG INSIDE OF DOTTED LINE
Ophiuchus
Serpent Wrestler
Serp
Hercules
Hero
C. Bo
Nor
Lyra
Harp
Vulpecula
Fox
Sagitta
Arrow
Aquila
Eagle
18 hr
Dec 20
GLUE EDGE
GLUE EDGE

CUT ALONG INSIDE OF DOTTED LINE


Sagittarius
Archer
-20°
Jan 20
Capricornus
Sea Goat
-10°
20 hr
0°
IN
10°
© Uni

DASH—IN



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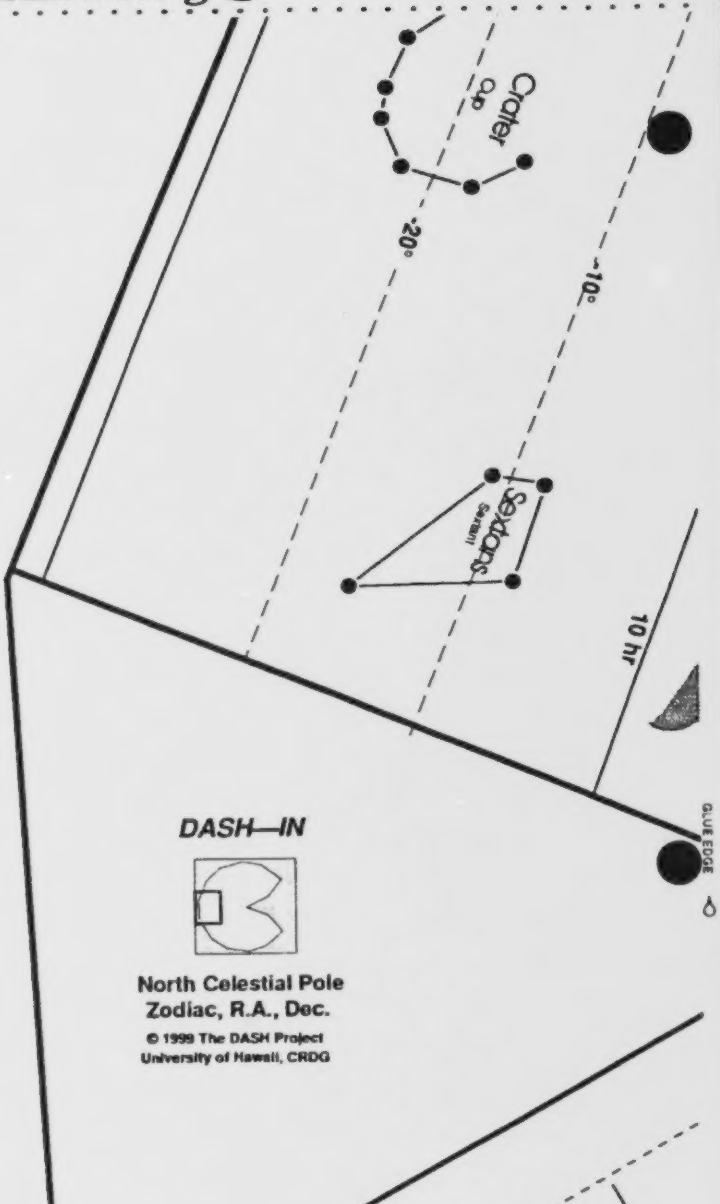
GLUE EDGE 6

CUT ALONG INSIDE OF DOTTED LINE


Crater
Cup
-20°
-10°
Sextans
Sextant
10 hr
GLUE EDGE
Hydra
Sea Serpent
-10°
-20°
GLUE EDGE

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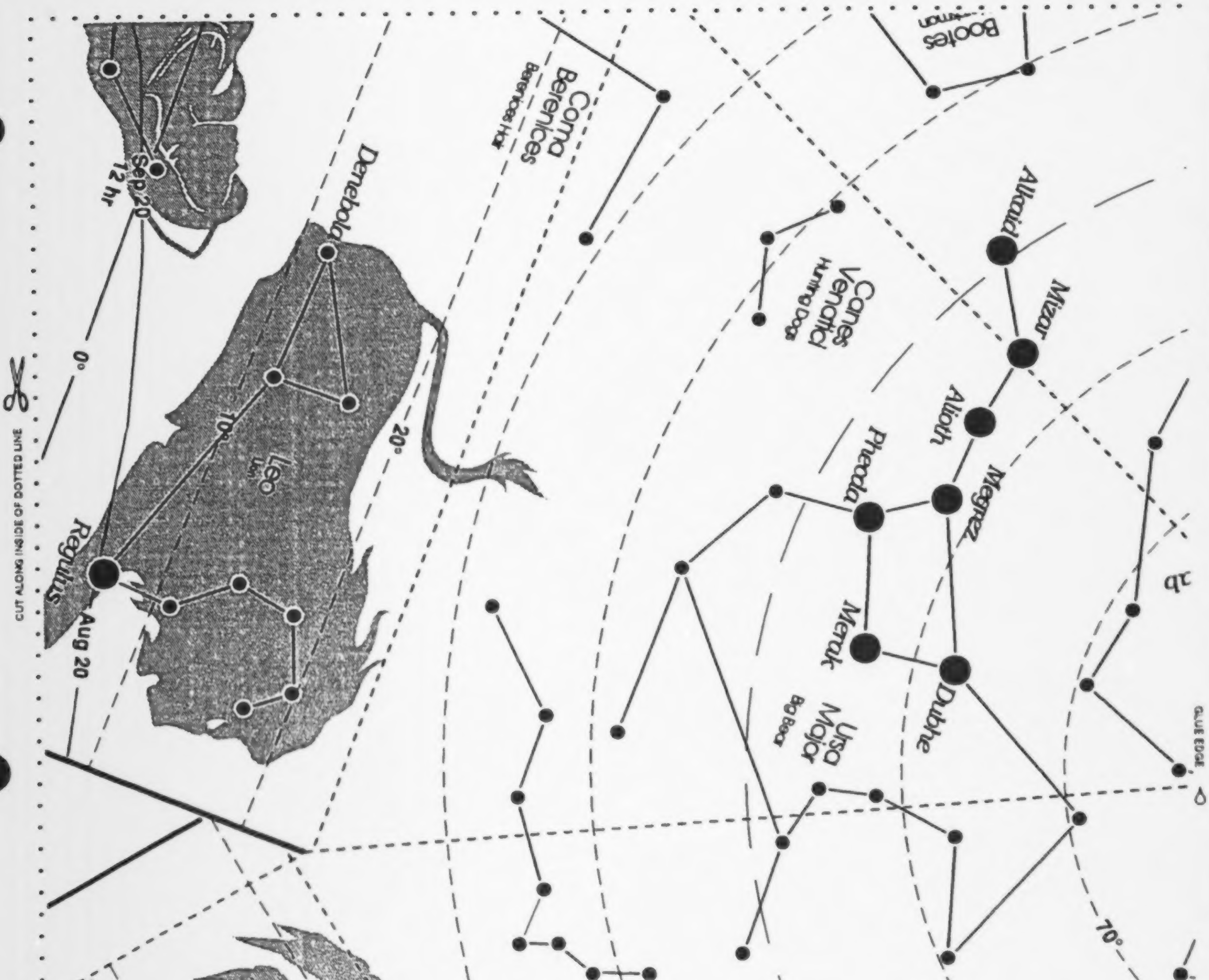
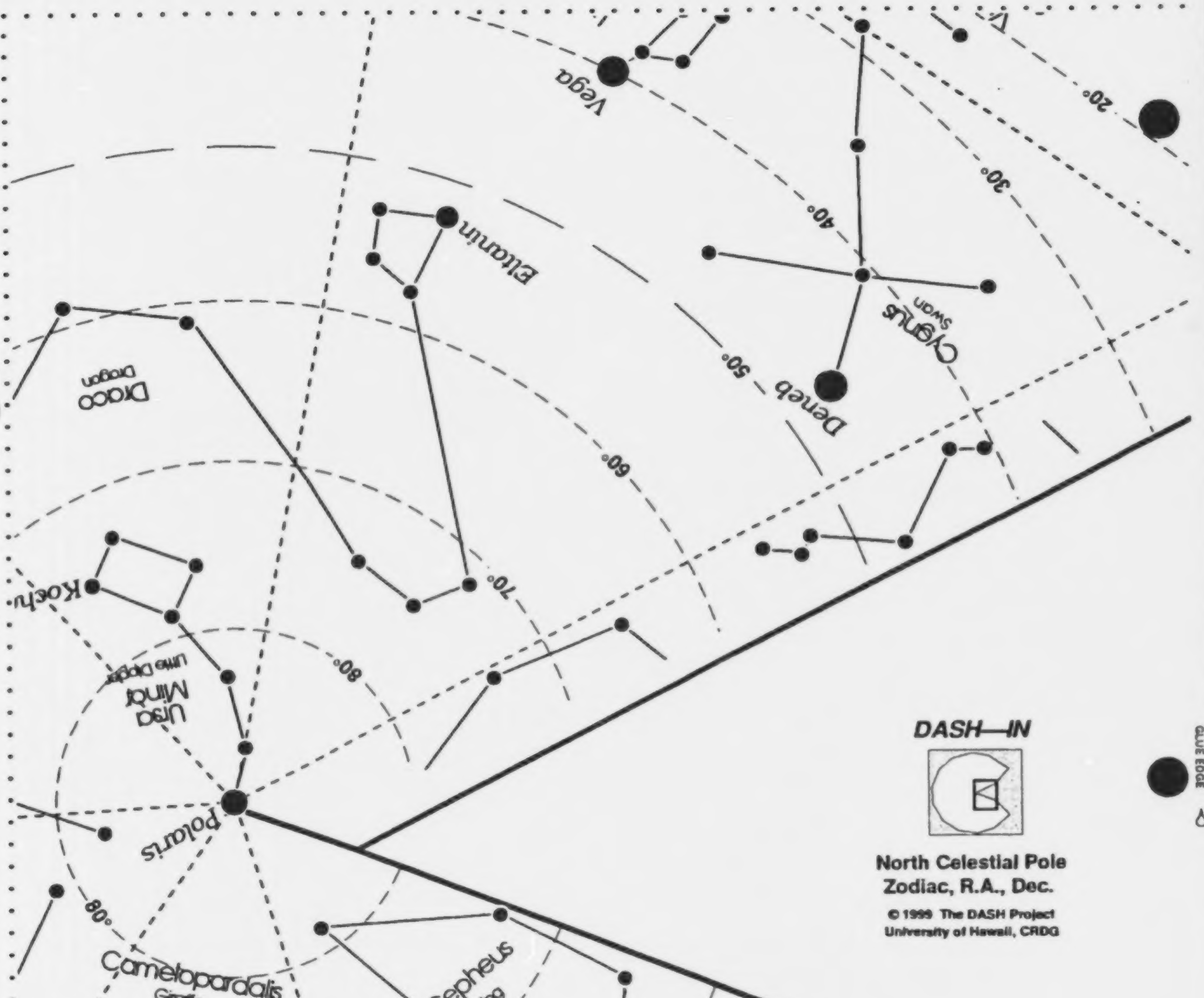

Bootes
Alkaid
Mizar
Alioth
Megrez
Phecda
Merak
Dubhe
Ursa Major
Big Bear
Canes Venatici
Hunting Dogs
Coma Berenices
Berenice's Hair
Denebola
Leo
Lion
Regulus
Aug 20
Sep 20
12 hr
0°
10°
20°
30°
40°
50°
60°
70°
Lynx
Lynx
Cancer
Crab
Jul 20
Castor
Pollux
Gemini
Twins
Canis Minor
Little Dog
08 hr
Cap
Auriga
CUT ALONG INSIDE OF DOTTED LINE
GLUE EDGE
GLUE EDGE


Vega
20°
30°
40°
Eltanin
Cygnus
Swan
Draco
Dragon
50°
Deneb
60°
70°
Koch
80°
Ursa
Minor
Little Dipper
Polaris
80°
Camelopardalis
Giraffe
Cepheus
King
Cassiopeia
Queen
Lacerta
Lizard
Scheat
Andromeda
Princess
Alpheratz
ella
Perseus
Hero
Pegasus
ed Horse

CUT ALONG INSIDE OF DOTTED LINE

GLUE EDGE

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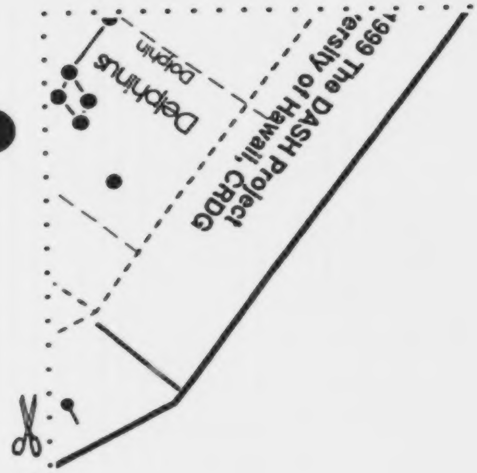
GLUE EDGE


1999 The DASH Project
ersity of Hawaii, CRDG
Delphinus
Delphin

CUT ALONG INSIDE OF DOTTED LINE

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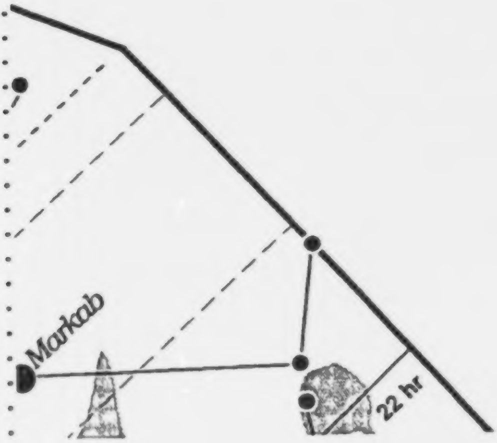
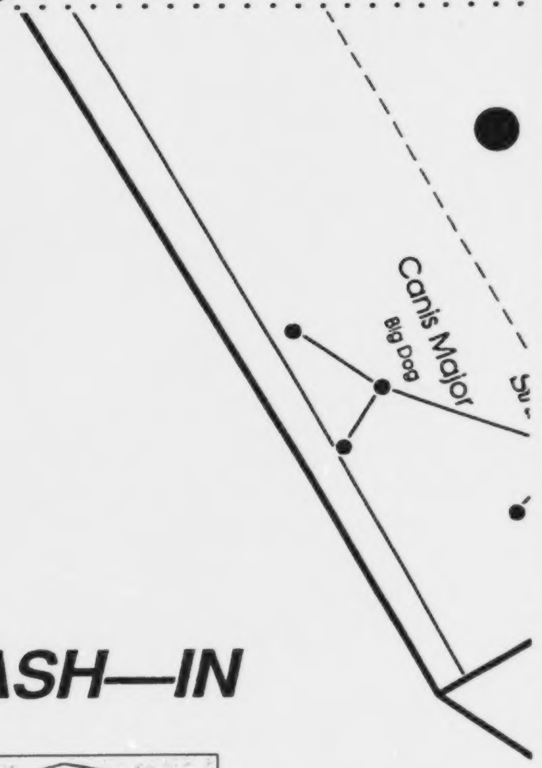
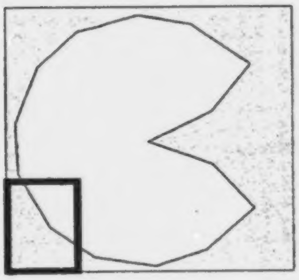

Markab
22 hr

GLUE EDGE 6


Canis Major
Big Dog

GLUE EDGE

DASH—IN



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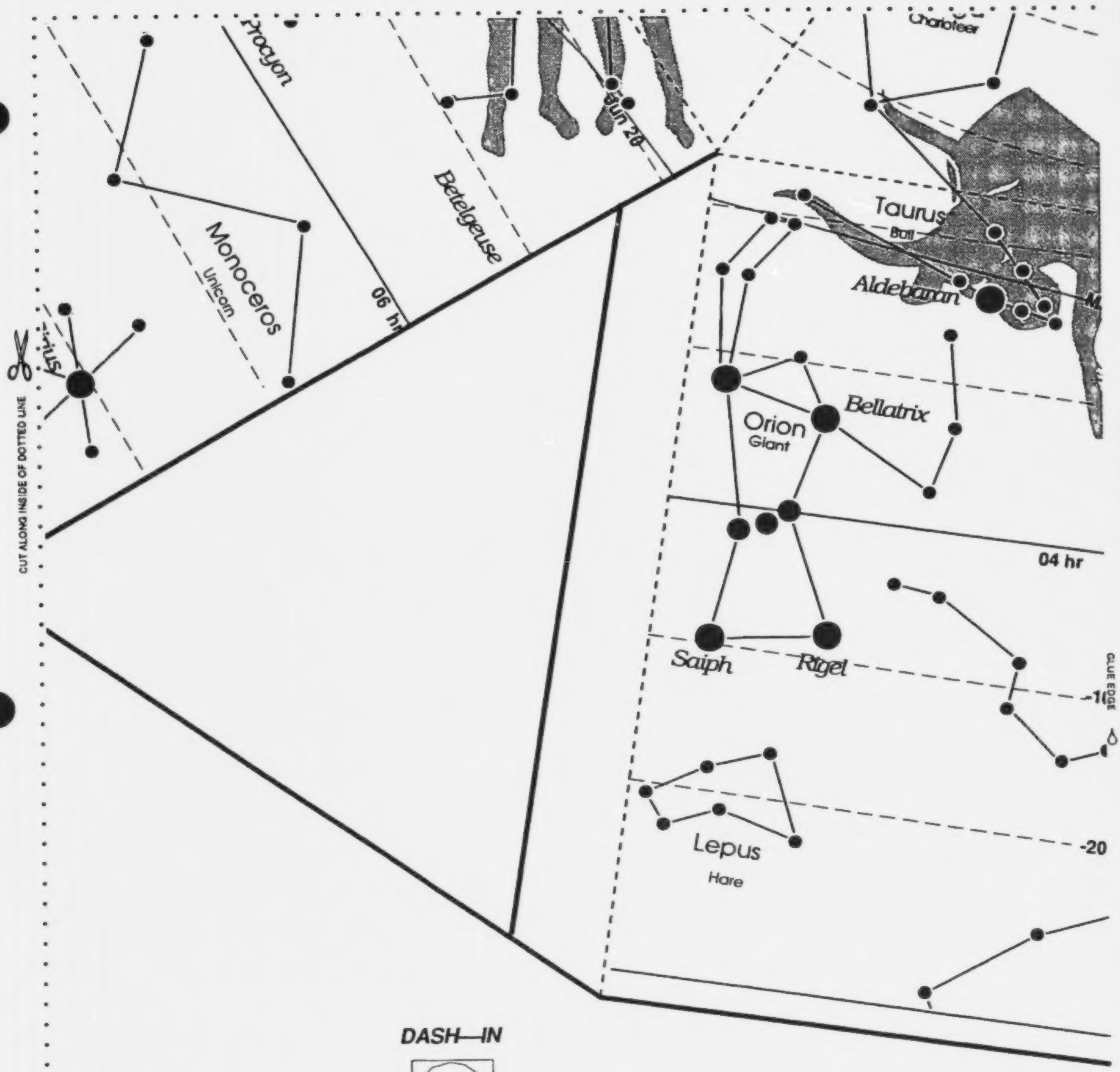
Charioteer
Procyon
un 28
Betelgeuse
Monoceros
Unicorn
06 hr
irius
CUT ALONG INSIDE OF DOTTED LINE
Taurus
Bull
Aldebaran
Orion
Giant
Bellatrix
04 hr
Saiph
Rigel
-1
GLUE EDGE
Lepus
Hare
-20

DASH—IN

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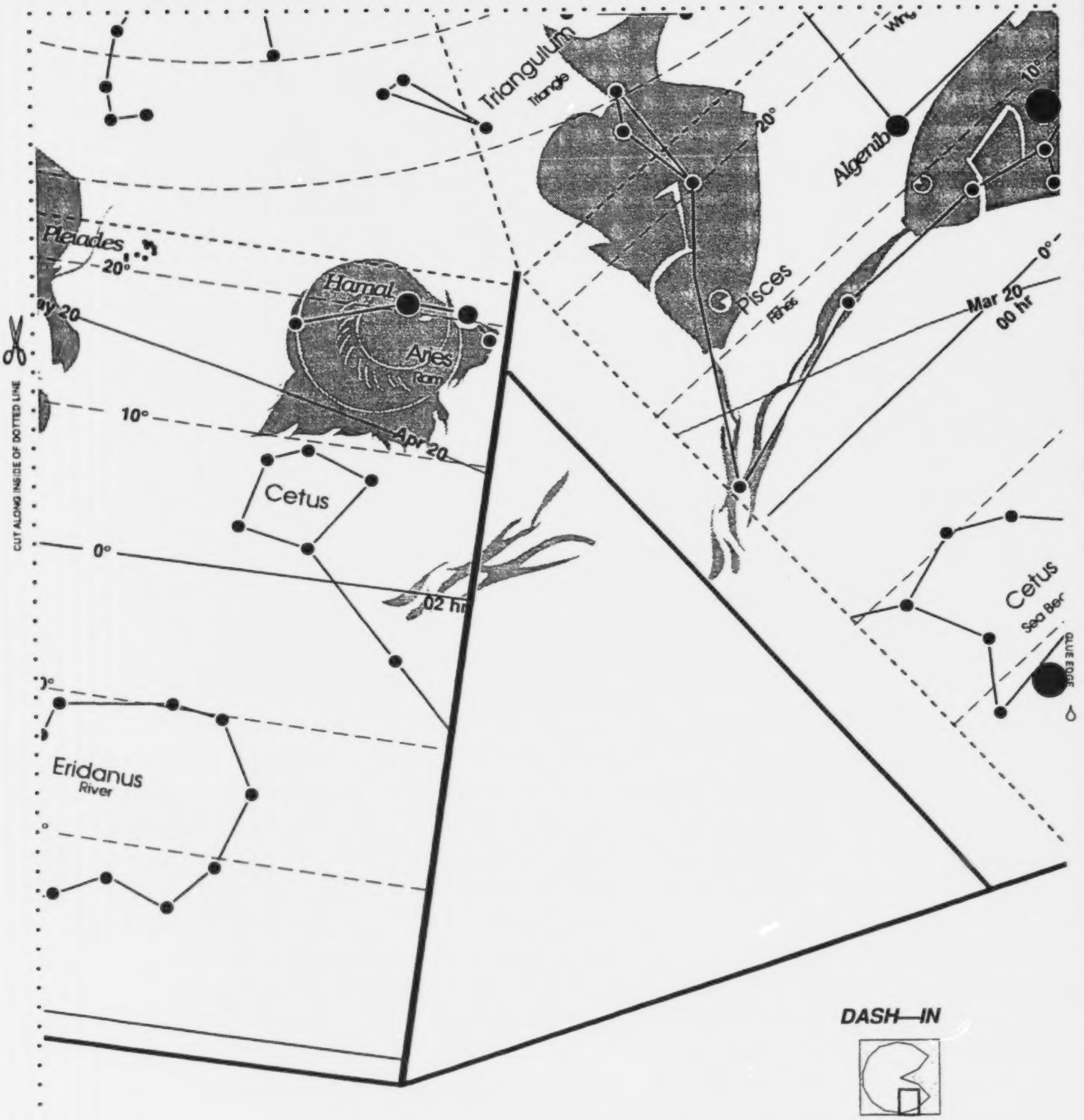
Triangulum
Triangle
Algenib
20°
10°
Pleiades
20°
Hamal
ay 20
Aries
Ram
Pisces
Fishes
0°
Mar 20
00 hr
10°
Apr 20
Cetus
0°
02 hr
Cetus
Sea Bea
Eridanus
River
CUT ALONG INSIDE OF DOTTED LINE
GLUE EDGE

DASH—IN

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Zodiac, R.A., Dec.

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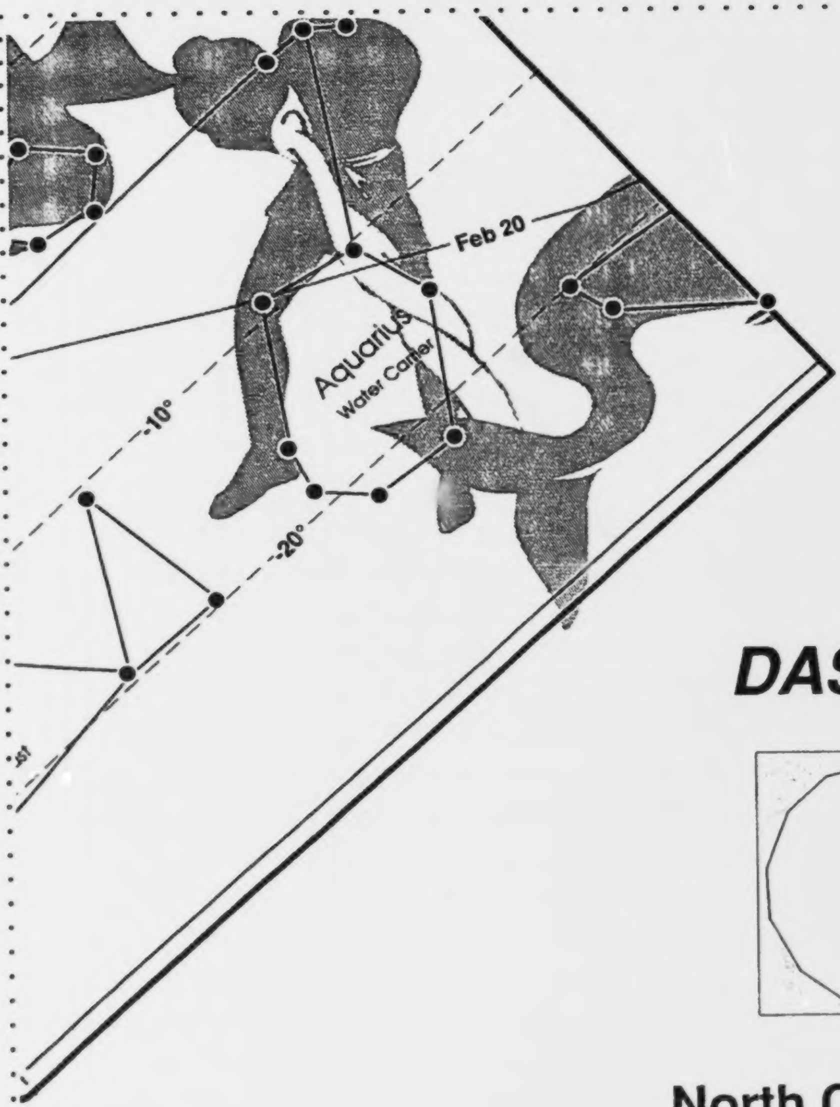
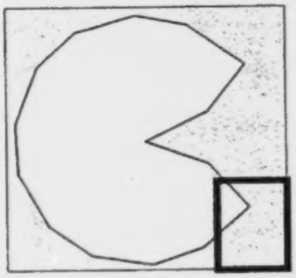
CUT ALONG INSIDE OF DOTTED LINE


Feb 20
Aquarius
Water Carrier
-10°
-20°
-30°

DASH—IN



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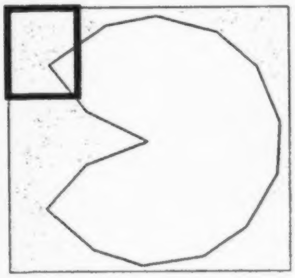

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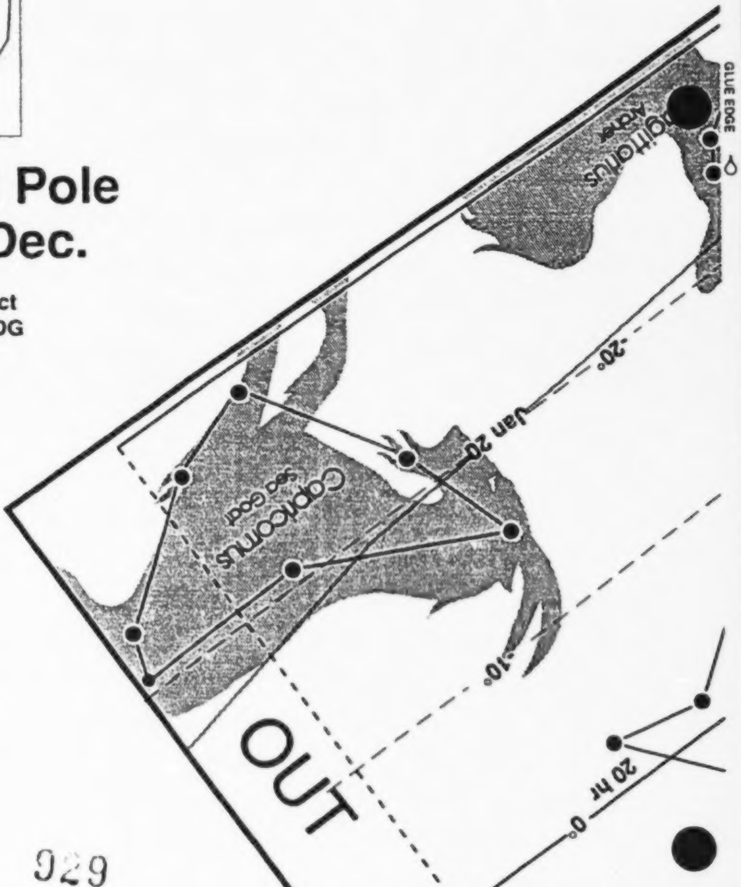
GLUE EDGE
Sagittarius
Archer
Capricornus
Sea Goat
Jan 20
-20°
-10°
0
20 hr
OUT

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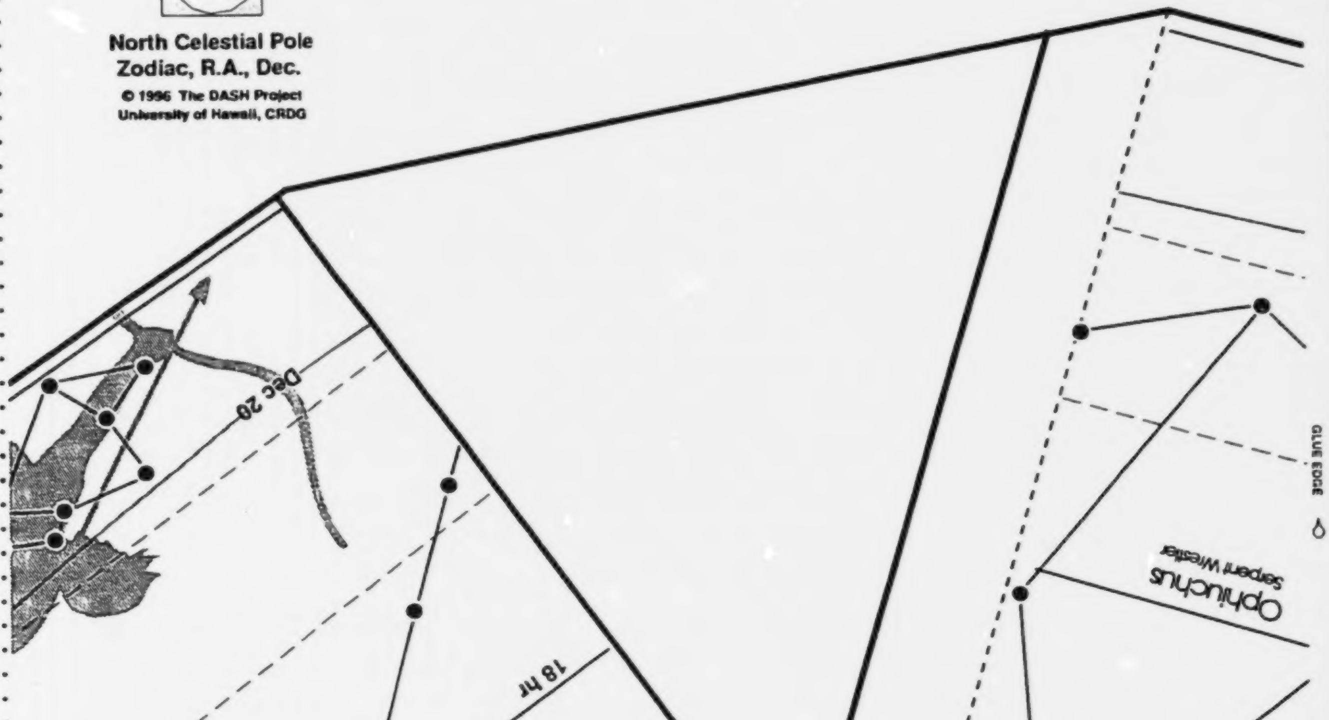
CUT ALONG INSIDE OF DOTTED LINE


Dec 20
18 hr
17 hr
Ophiuchus
Serpent Wrestler
GLUE EDGE
Aquila
Eagle
Altair
10°
Sagitta
Arrow
Vulpecula
Fox
Lyra
Harp
Hercules
Hero

GLUE EDGE

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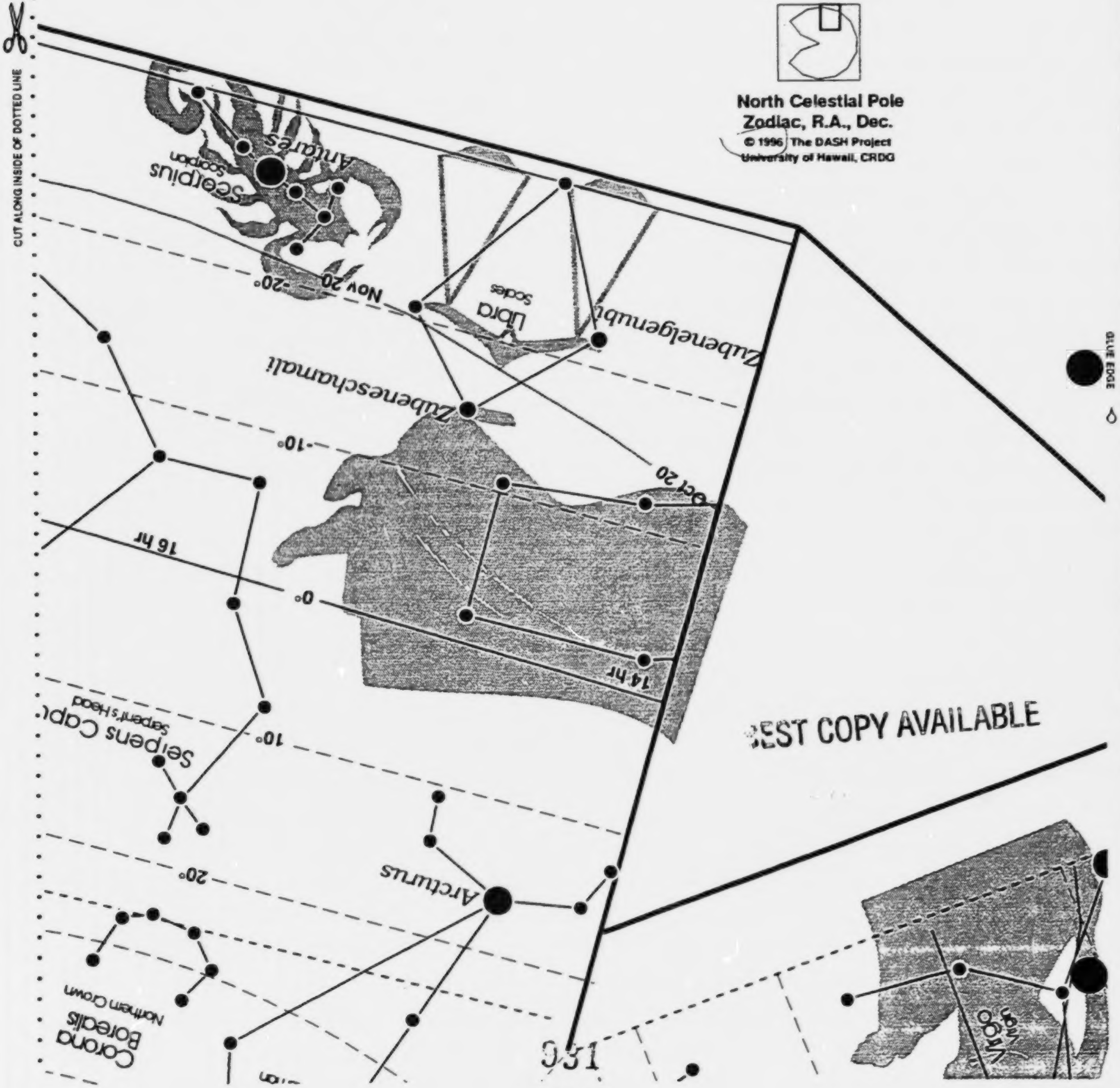
CUT ALONG INSIDE OF DOTTED LINE


Scorpius
Scorpion
Antares
Libra
Scales
Zubenelgenubi
Zubeneschamali
Nov 20
-20°
-10°
Oct 20
16 hr
0°
14 hr
Serpens Caput
Serpent's Head
10°
20°
Arcturus
Corona Borealis
Northern Crown
Virgo
Virgin

GLUE EDGE

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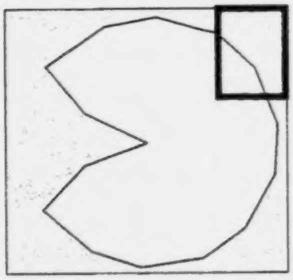
GLUE EDGE

CUT ALONG INSIDE OF DOTTED LINE

DASH—OUT



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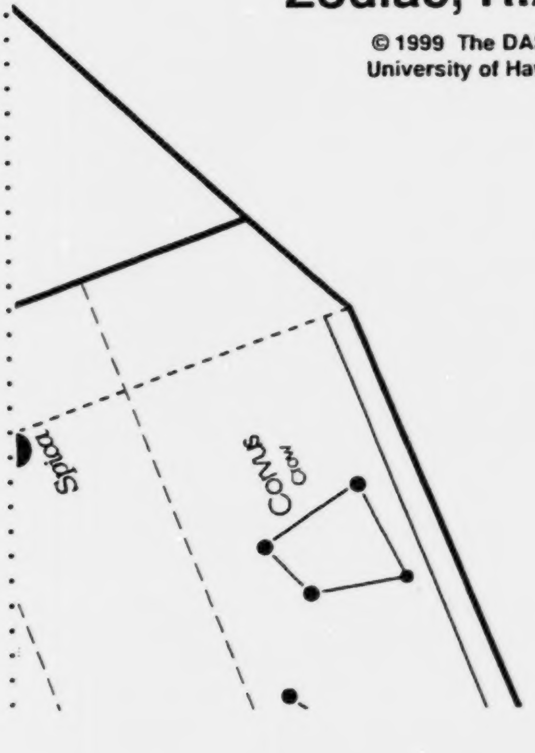
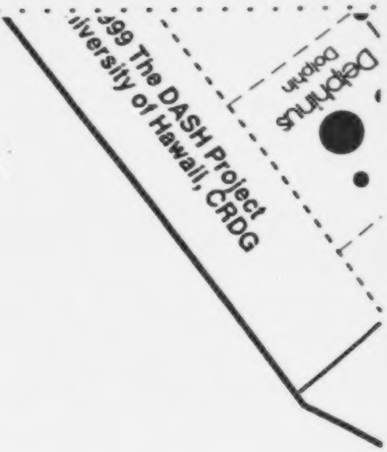

Spica
Corvus
Crow

GLUE EDGE

CUT ALONG INSIDE OF DOTTED LINE


999 The DASH Project
iversity of Hawaii, CRDG
Delphinus
Dolphin

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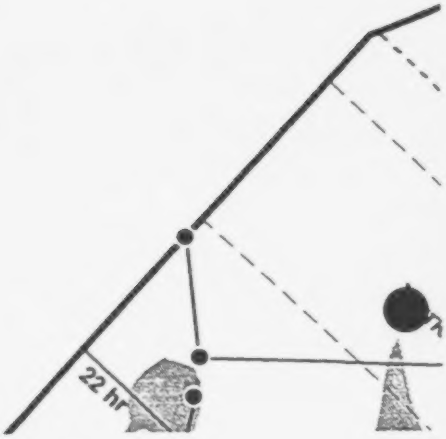
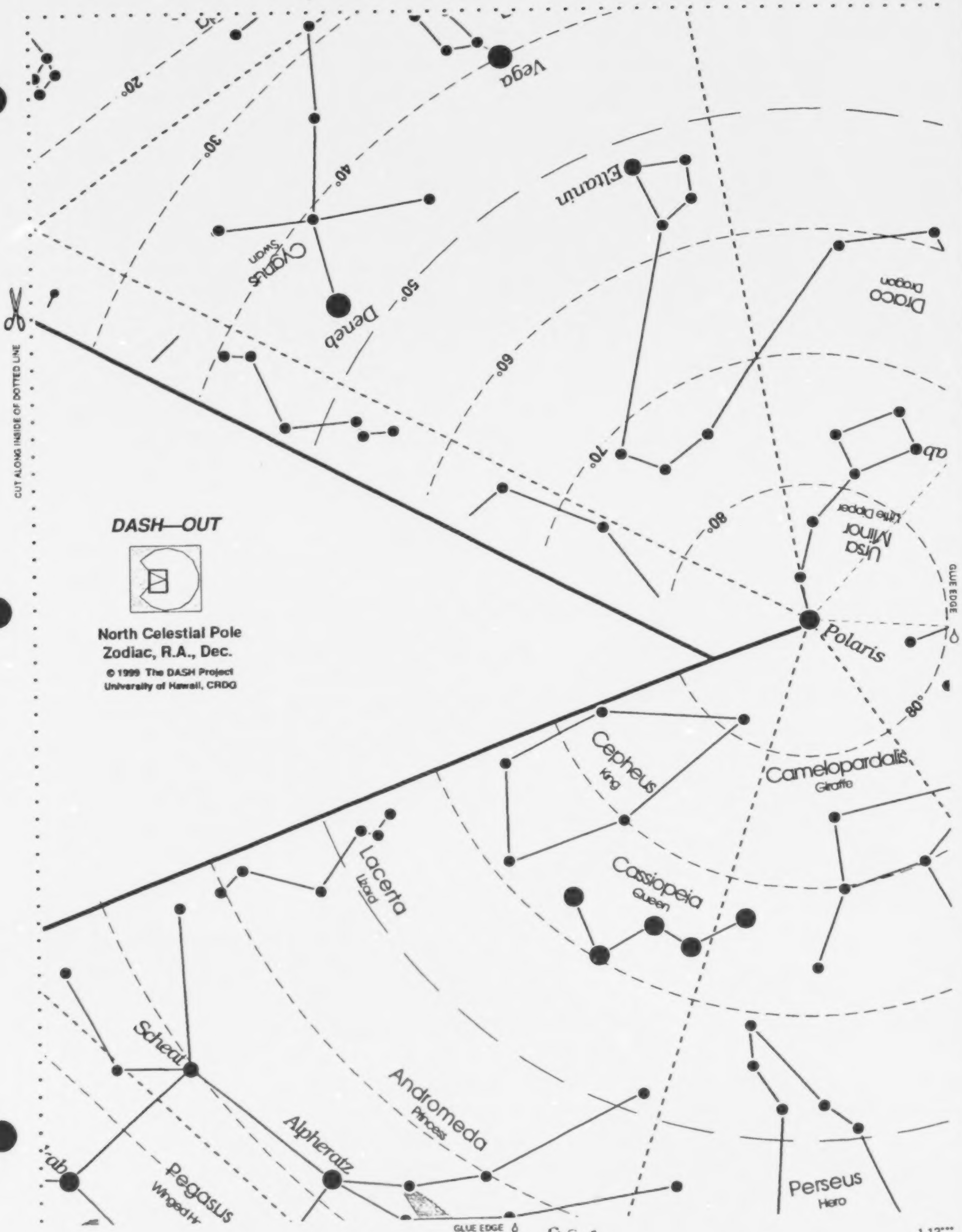
GLUE EDGE 6



GLUE EDGE 6


CUT ALONG INSIDE OF DOTTED LINE
20°
30°
40°
50°
60°
70°
80°
80°
Vega
Eltanin
Cygnus
Swan
Deneb
Draco
Dragon
Ursa Minor
Little Dipper
Polaris
GLUE EDGE
Cepheus
King
Camelopardalis
Giraffe
Lacerta
Lizard
Cassiopeia
Queen
Scheat
Andromeda
Princess
Alpheratz
Pegasus
Winged H
Perseus
Hero
GLUE EDGE

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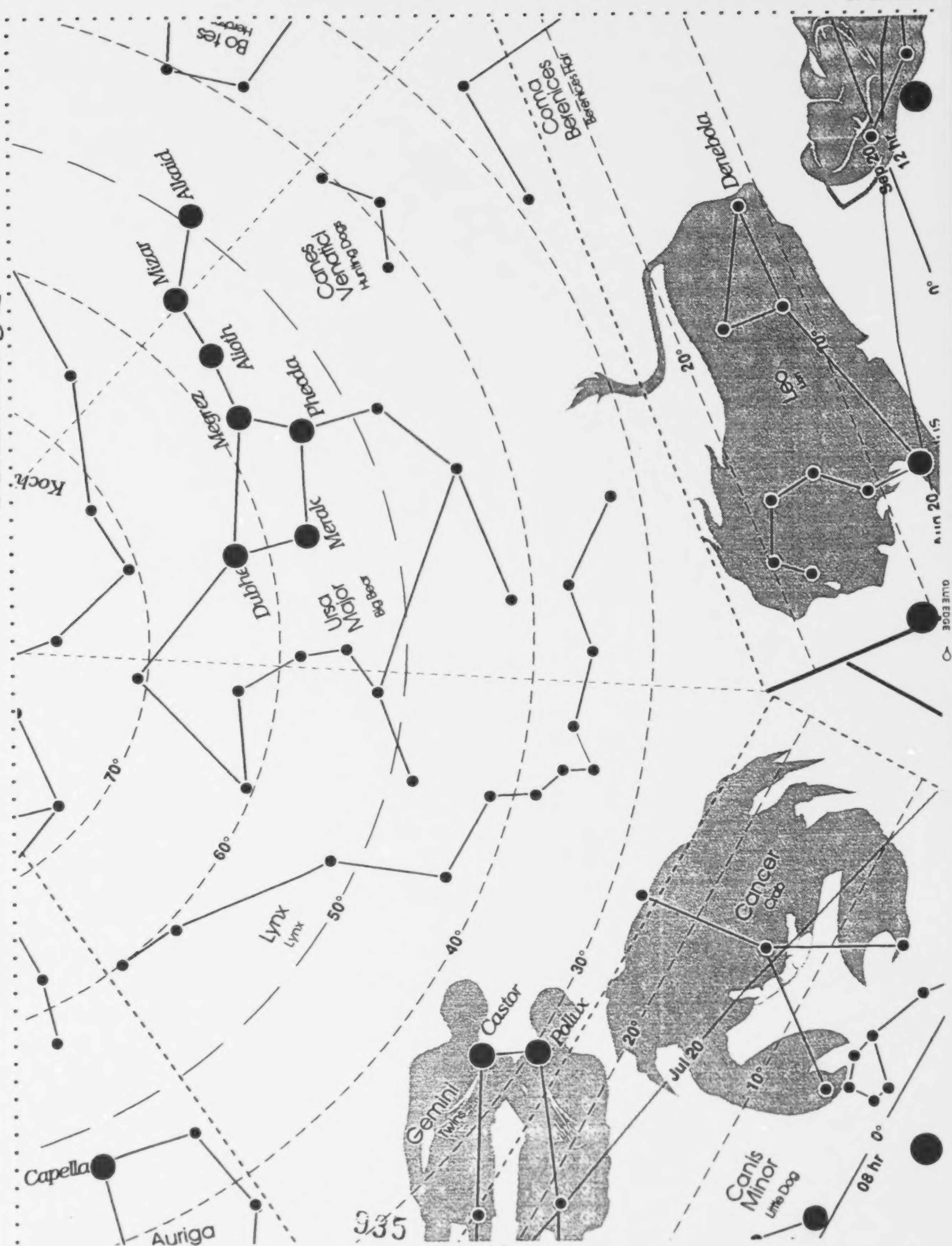
CUT ALONG INSIDE OF DOTTED LINE


Bo tes
Herdsman
Coma
Berenices
Berenice's Hair
Denebola
Alkaid
Mizar
Alioth
Megrez
Phecda
Merak
Dubhe
Canes
Venatici
Hunting Dogs
Ursa
Major
Big Bear
Leo
Lion
Koch.
70°
60°
50°
40°
30°
20°
10°
0°
Lynx
Lynx
Capella
Auriga
Gemini
Twins
Castor
Pollux
Cancer
Crab
Canis
Minor
Little Dog
08 hr
Jul 20
Aug 20
Sep 20
12 hr

GLUE EDGE

GLUE EDGE

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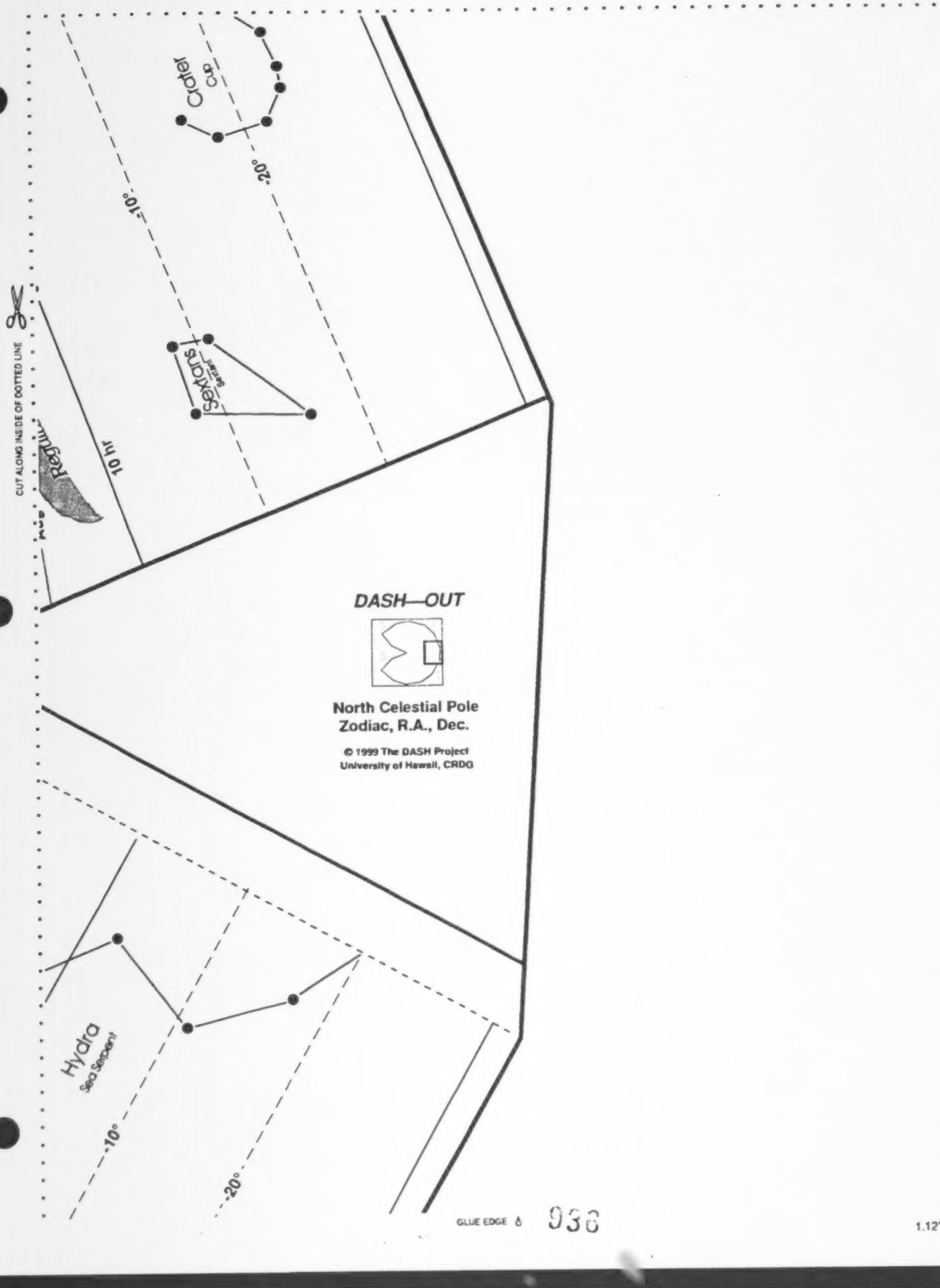
Crater
Cup
-20°
-10°
CUT ALONG INSIDE OF DOTTED LINE
Sextans
Sextant
Regul
10 hr
Hydra
Sea Serpent
-10°
-20°
GLUE EDGE 8

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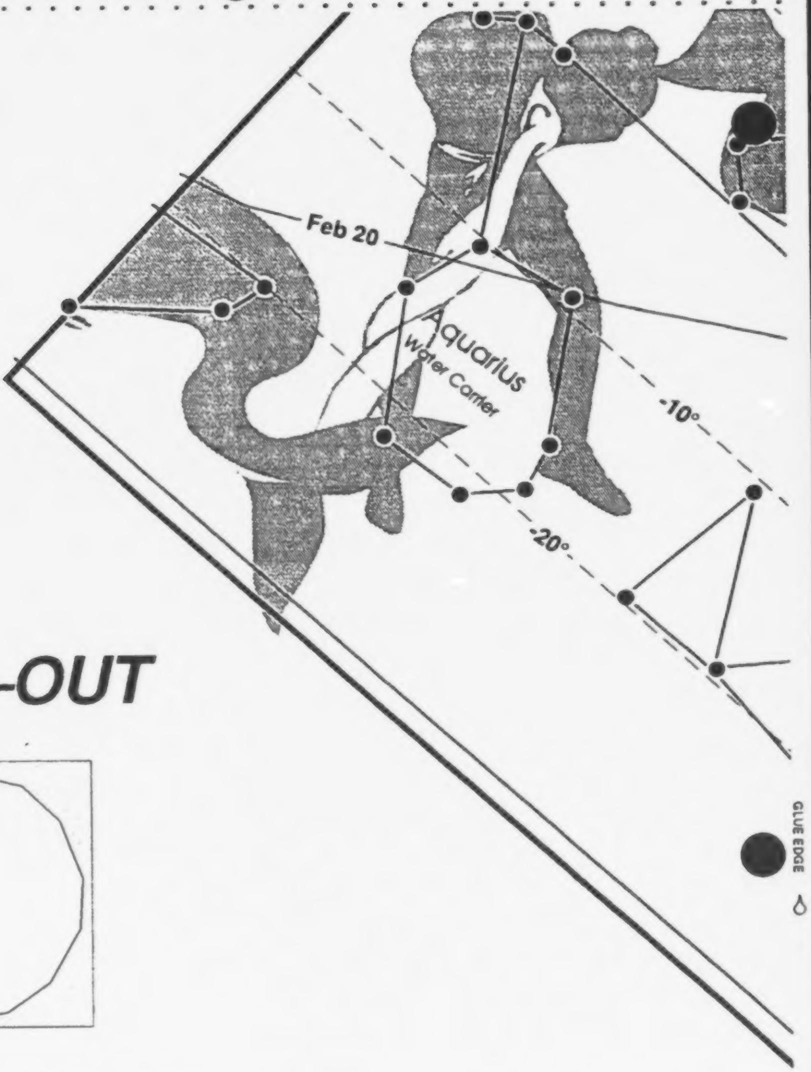
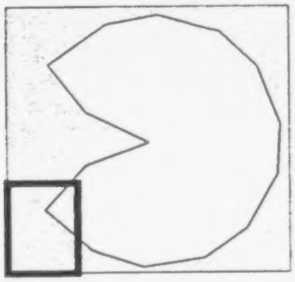
CUT ALONG INSIDE OF DOTTED LINE


Feb 20
Aquarius
Water Carrier
-10°
-20°
GLUE EDGE

DASH—OUT



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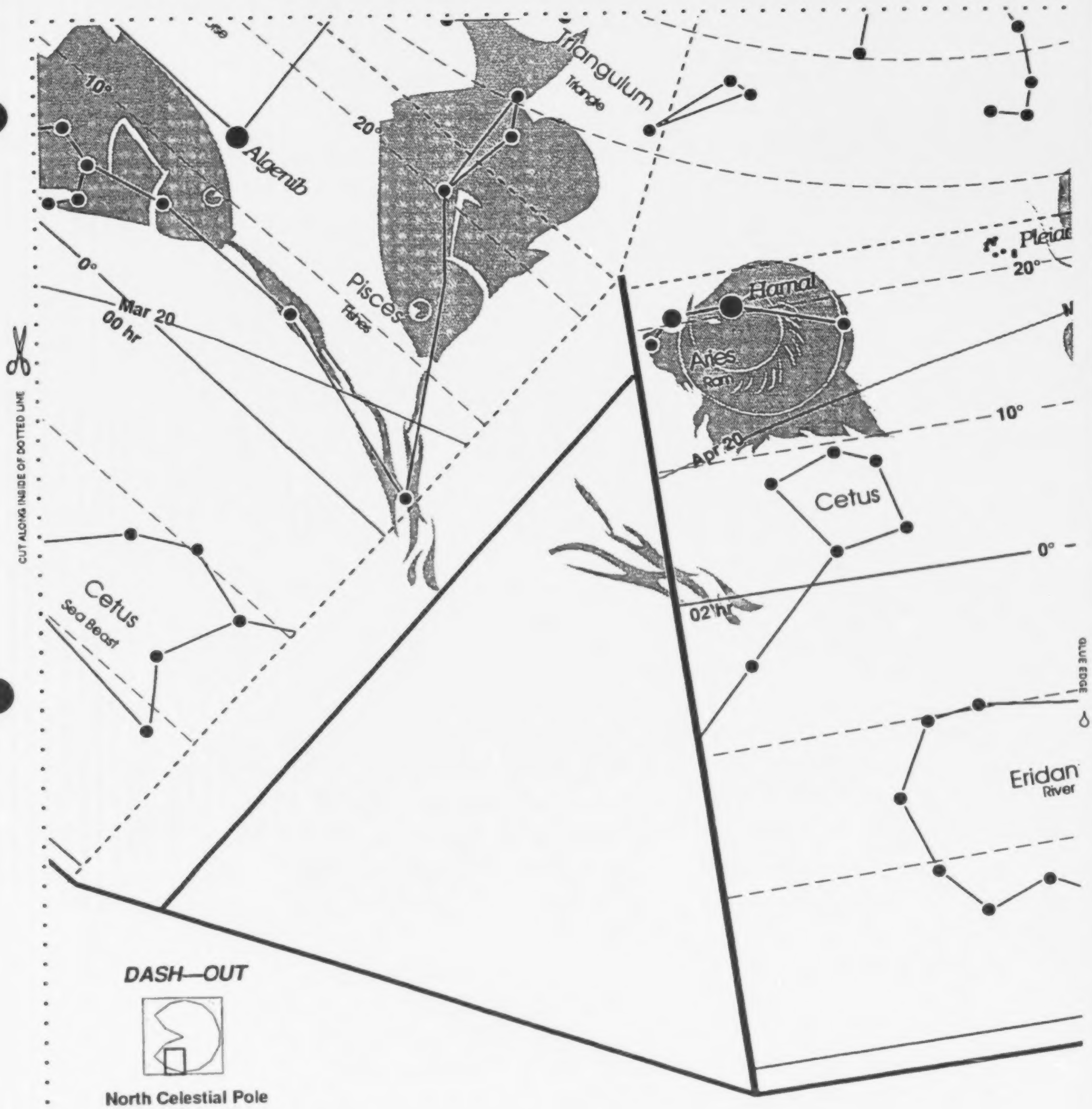
Triangulum
Triangle
10°
Algenib
20°
0°
Mar 20
00 hr
Pisces
Fishes
Pleiad
20°
Hamal
Aries
Ram
10°
Apr 20
Cetus
0°
02 hr
CUT ALONG INSIDE OF DOTTED LINE
Cetus
Sea Beast
GLUE EDGE
Eridan
River

DASH—OUT

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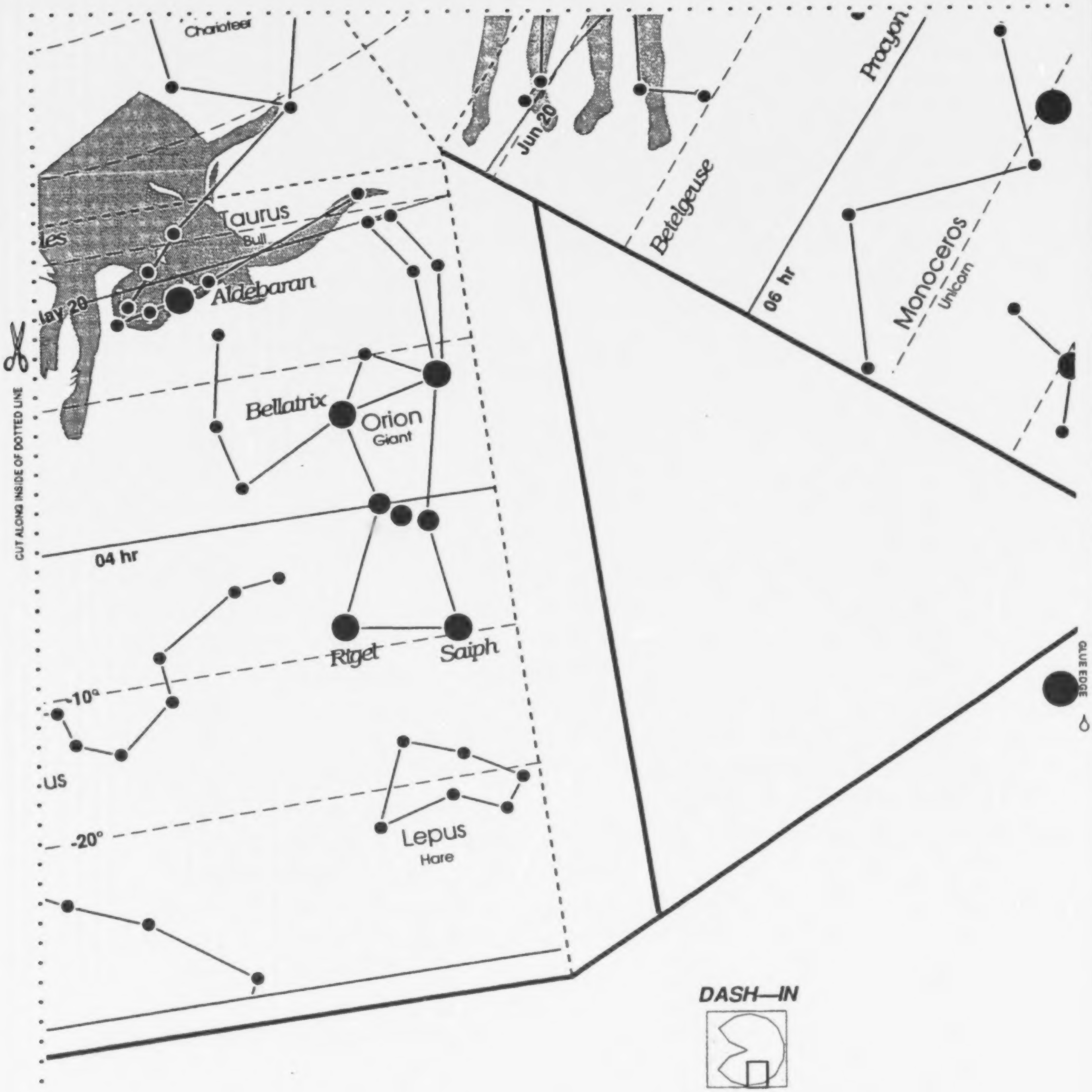
Charioteer
Jun 20
Procyon
Betelgeuse
Taurus
Bull
les
Aldebaran
lay 20
06 hr
Monoceros
Unicorn
Bellatrix
Orion
Giant
CUT ALONG INSIDE OF DOTTED LINE
04 hr
Riget
Saiph
GLUE EDGE
-10°
US
Lepus
Hare
-20°

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CUT ALONG INSIDE OF DOTTED LINE
Sirius
Canis Major
Big Dog

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Name______________________

Date______________________

DASH

STUDENT PAGE 5.7.2C ZODIACAL CONSTELLATIONS

Table 5.7.2 Zodiacal constellations and the sun

ZODIACAL CONSTELLATION	*DATES WHEN SUN IS IN THE CONSTELLATION
Capricornus, the Goat	January 19–February 15
Aquarius, the Water Bearer	February 16–March 11
Pisces, the Fishes	March 12–April 18
Aries, the Ram	April 19–May 13
Taurus, the Bull	May 14–June 20
Gemini, the Twins	June 21–July 19
Cancer, the Crab	July 20–August 9
Leo, the Lion	August 10–September 15
Virgo, the Virgin	September 16–October 30
Libra, the Balance	October 31–November 22
Scorpius, the Scorpion	November 23–December 17
Sagittarius, the Archer	December 18–January 18

*Adjust for Leap Years

1. Explain what we mean when we say that the sun is "in" a certain constellation.

____

____

____

2. Explain how you would orient your Planetarium when you are observing at night.

____

____

____

____

ACTIVITY 5.7.3 MAPPING THE SKY

OBJECTIVES

The students

- Use a model of Earth to study latitude and longitude.
- Review the relationship between time and longitude.
- Invent a way of finding longitude.
- Identify similarities between declination and latitude and right ascension and longitude.
- Find the coordinates of stars on their Planetarium.

BACKGROUND

This activity is the third in the wayfinding series. It should follow Activity 5.7.1 WHERE IN THE WORLD ARE WE? and 5.7.2 PLANETARIUM.

In MAPPING THE SKY the students assemble a model of Earth and suspend it inside a clock face. Using the model, they work with the relationship between time and degrees of longitude and are left with the problem of inventing a way to find longitude. They also review how to find latitude and finally relate latitude to astronomical declination and longitude to astronomical right ascension.

Longitude

Longitude gives a measure of the number of degrees a place is west or east of the prime meridian. The *prime meridian* is an imaginary half circle running from the North Pole to the South Pole over the observatory at Greenwich, England. The prime meridian is also called the *Greenwich* or *0° meridian*. Longitude can be found by determining the time difference between local noon and Greenwich time. *Greenwich time* refers to the time along the prime or 0° meridian. *Local noon* is found when the sun is in the middle of its daily travel from east to west and makes the shortest shadow of the day.

- Every hour of difference in time between Greenwich time and local noon equals 15°.
- Twenty-four hours divides into 360° to give us 15° per hour, and 15° divided into 60 minutes gives us 4 minutes per 1°.

If we are at a place where it is 1200 hours local noon and it is 1500 hours at the prime meridian, we are 45° west of the prime meridian. It is earlier at that location than at the prime meridian. Because the sun moves from east to west, time west of the prime meridian will always be earlier than at the prime meridian up to the 180° meridian. Times east of the prime meridian up to the 180° meridian will be later than the time at the prime meridian.

One more example, if we are at a place where it is 1200 hours local noon and it is 0800 hours at the prime meridian, we are 60° east of the prime meridian. It is four hours later at that location than at the prime meridian (4 hours x 15°/hour = 60°). Again, because the sun moves from east to west, time east of the prime meridian will be later than that of the prime meridian.

Latitude

Latitude is the number of degrees a place is from Earth's equator. In the Northern Hemisphere it can be found by measuring the number of degrees the North Star (Polaris) is above the northern horizon. See Figure 5.7.3(1). Latitude can also be measured as the angle made by the shadow of a gnomon at the equinox.

Right Ascension and Declination

The students find that the sky too is laid out in coordinates. *Right ascension (R.A.)* corresponds to longitude and is measured in hours, minutes, and seconds. *Declination* corresponds to terrestrial latitude and is measured in degrees.

The imaginary sphere of the heavens is marked off in a grid system. Declination runs from 0° at the equator to +90° at the north celestial pole and from 0° to -90° at the south celestial pole. Right ascension at the celestial equator starts at 0 hours in Pisces and passes around the sky in a great circle back to 24 hours at the starting point in Pisces. See Figure 5.7.3(2).

Finding Right Ascension

A group of three bright stars on the celestial equator is found in the belt of the constellation Orion. These stars have a right ascension of about 6 hours. With these stars as locators, the students can use their fists to find the approximate right ascension of other stars. See Figure 5.7.3(2). Each hour equals 15° of right ascension. It takes 24 hours for Earth to turn through 360°; therefore, in each hour it turns through 15°. Each fist measures 10°; therefore, 15° is equal to a fist and a half. Six hours will be 90° R.A. or 9 fists.

- Orion's Belt is about 6 hours, 9 fists, or 90° R.A. to the east of the 0-hour point in Pisces.

- The 12-hour R.A. position will be 9 more fists or 90° to the east of Orion's Belt.
- The 18-hour R.A. position will be 18 fists or 180° to the east of Orion's Belt.
- The 24-hour R.A. position (and we are back to 0 hours) will be 27 fists or 270° to the east of Orion's Belt or 9 fists west of it.

Finding Declination

The declination of a star is the number of degrees it is from the celestial equator, which has a declination of 0°. The declination of the North Star is +90°, and the declination of the spot directly over the South Pole is -90°. We can approximate the declination of a star by finding how many fists it is down from the North Star and subtracting from +90°.

For example, a star 3 fists below the North Star has a declination of +60°. It is 3 fists or 30° below the North Star, and +90° – 30° = +60°. One more example, a star 10 fists below the North Star has a declination of -10°. Ten fists are equal to 100°, and +90° – 100° = -10°. This is 10° below the celestial equator.

Barry's Doggerel

To solidify the concepts of the activity use Barry's doggerel. If time is short, move to Activity 5.7.4 after Procedure 7.

STUDENT ROLES

Astronomers
Navigators

MATERIALS

plastic wrap
glue
scissors
tape
yellow and black marking pens
Planetarium
Student Pages 5.7.3A MAPPING THE SKY
5.7.3B BARRY'S WAYFINDING: LONGITUDE AND LATITUDE
5.7.3C BARRY IN SPACE: DECLINATION AND RIGHT ASCENSION

PRODUCTS

Models of Earth and time
Completed Student Pages

PROCEDURES

1. **Tell the students that now that we have some understanding of how to map Earth, we will map the heavens. To give the students a sense of how this can be done, have them assemble a model of Earth from the diagram in Student Page 5.7.3A MAPPING THE SKY. See Figure SP 5.7.3A(1).**

2. **Have them cut out the center of the two clock-face rings (top and bottom) and glue them together back to back with a sheet of plastic wrap sandwiched between. The Earth model can sit in the center of the ring and be viewed from top and bottom. See Figures SP 5.7.3A(2-3).**

   Help the students make sure that
   - The clock-face rings revolve from east to west as the sun travels.
   - The 0600–1800 segments are colored yellow on both sides of the clock to register day and night at the equator.

3. **Use the models to expand on the relationship between time and longitude.**

   Ask such questions as these:
   - Where is the starting point for measuring longitude? (Identify the prime meridian or 0° longitude point through Greenwich, England. This is the site of a famous British observatory.)
   - Where is the east and where is the west when standing at 0° longitude? (Everything toward the Americas is west; everything toward Asia is east.)
   - If we place our Earth model on the clock face so that midnight is at the prime meridian, where will the noon position be? (Have the students carry out the operation and work for agreement that it will be at 180° E or 180° W.)
   - What will be directly above the 180° meridian of longitude? (Work for agreement that this where the sun will be.)

- Using the model, when it's midnight at the prime meridian, where will it be 1:00 A.M. or 0100 hours? (Develop the observation that it will be 0100 hours east of the prime meridian.)
- Using the model, when it's midnight at the prime meridian, where will it be 1:00 P.M. or 1300 hours? (Note that it will be 1300 hours 1 hour east of the 180° meridian or at 165° W.)
- When it's 4:00 A.M. or 0400 hours at the prime meridian, where will it be 4:00 P.M. or 1600 hours?
(Work for agreement that it will be on the 180° meridian.)
- When it is noon at 60° W longitude, what will be the time on the prime meridian? (Work for agreement that it will be 1600 hours.)

4. **Have the students work in small groups to give each other challenge times and longitudes until they have some facility. Then continue with observation of the model.**

Ask such questions as these:

- Through how many degrees does Earth seem to move in an hour? How do you explain your answer? (The students may come up with several approaches. Work to something like this: The 24-hour clock and the circles of latitude of Earth are all circles of 360°. The sun seems to move 1/24 of the way around in one hour. One twenty-fourth of 360° is equal to 15° per hour. Therefore, when the prime meridian is at the midnight position, the one hour after midnight point is 15° east of the prime meridian and the one hour before midnight or 2300 hours is 15° west of the prime meridian.)
- How many minutes represent a single degree? (Work to the idea that 1° is 1/15 the distance the sun seems to travel in an hour. Sixty minutes divided by 15 makes it 4 minutes per degree.)
- What instrument could we use to find our longitude on Earth? (Let the students invent a way to find longitude. Give them day or so to work on the problem. The historical answer was to carry a timepiece set for Greenwich time and then determine when it was midday or noon locally. Each hour of difference multiplied by 15° tells how far a person is from the prime meridian. Meanwhile continue with Procedure 5.)

5. **Have the students place their Planetariums next to the Earth model when it is on top of the clock-face rings.**

Ask such questions as these:

- Where is the north celestial pole of the Planetarium? (Help the students identify the North Star (Polaris) as being at the celestial pole.)
- Where would the celestial equator be? (Help the students hypothesize that it is halfway between the north and south celestial poles as the equator of Earth is halfway between the terrestrial poles.)
- What do we mean by "global coordinates"? (Help the students recall that these are points of intersection of latitude and longitude measurements on a map or globe of the world.)
- How could we get celestial coordinates? (Work to the idea of marking models of the heavens with imaginary lines the same way we mark Earth into imaginary coordinates.)
- Does anyone know what corresponds to the circles or parallels of latitude on the Planetarium? (Introduce the term *declination.* Some students may have already connected this term with *magnetic declination*, which is the turning aside from true celestial north caused by the magnetic poles of Earth. Here the term refers to the angular turning away from the celestial pole.)
- Can you find the 0° declination on your Planetarium? Where is it? (Help the students see that it is the circle of the celestial equator.)
- Can you find the +90° declination? Where is it? (Help the students see that it is at the celestial north pole. The arc between the north celestial pole and the celestial equator is divided into 90°, with 0° at the celestial equator and 90° at the celestial pole.)
- If we were standing on the North Pole of Earth, what would be the celestial declination directly overhead? (Work to the idea that it would be the celestial north pole or +90°.)
- If we were standing on the equator of Earth, what would be the celestial declination of the point directly overhead? (Work to the idea that it would be the celestial equator or 0°. Extend to the idea that our terrestrial or earthly north latitude will always have an overhead declination with the same number of degrees.)
- What would be the south declination above 20° S latitude? (Probe for the logic that all points directly overhead should have the same numerical declination as the latitude where an observer stands. Further, if northern hemispheric skies are plus [+], southern hemispheric skies would probably be minus [-]. The declination would be -20°.)

- Does anyone know what corresponds to longitude? (Introduce the term *right ascension [R.A.]*.)
- Can you find the 0-hour right ascension on your Planetarium? Where is it? (Help the students locate it in the zodiacal region of Pisces. This is the time of the spring equinox.)
- How does right ascension seem to be measured? (Work for agreement that it is measured in hours.)
- How many hour divisions are there along the celestial equator? (Work for the idea that there are 24, the same number as found on a 24-hour clock. The 24th hour is also the same as the 0 hour.)

6. **Have the students locate the following stars on the Planetarium and give their coordinates.**

STAR	CONSTELLATION	RIGHT ASCENSION	DECLINATION
Sirius	Canis Major	6 hr 45 min	-20.0°
Arcturus	Boötes	14 hr 15 min	+19.0°
Vega	Lyrae	18 hr 35 min	+38.5°
Capella	Auriga	5 hr 15 min	+46.0°
Rigel	Orion	5 hr 15 min	-8.0°

7. **Have the students list the coordinates of other stars. Then have them see whether their partners can find the stars.**

8. **Have the students read Student Pages 5.7.3(B–C) BARRY'S WAYFINDING and BARRY IN SPACE and explain how the doggerel gives direction for finding locations on Earth and in space.**

Ask such questions as these:

- How does Barry find latitude? (Develop the idea that latitude is equal to the number of degrees the North Star is above the northern horizon. This can be measured using one's fists.)
- How does Barry find longitude? (Develop the idea that longitude can be found by finding how many hours local noon comes before or after noon at Greenwich. Each 4 minutes of time is 1° of longitude. See Figure 5.7.3[1].)
- How can we determine when it is local noon? (Work for the idea that local noon comes when the sun casts its shortest shadow on the local north-south line.)
- How does Barry find the declination of a star? (Develop the idea that he uses his fist and subtracts the number of degrees from the Polaris +90° declination.)

- How does Barry find right ascension? (Develop the idea that he can count around the celestial equator using his fists. There are 24 hours in the celestial equatorial circle. As when we use time to measure longitude on Earth, each hour represents 15° of the equatorial circle. There are 15° per hour, and in our fist system where each 10° of arc is one fist, 15° will be one and a half fists.)
- Why did Barry use the stars of Orion's Belt? (Work for agreement that they are very bright, are on the equator, and are conveniently located about 6 hours or one-fourth the distance around the circle of the equator from the 0-hour point in Pisces. Pisces is not on the equator and is much more difficult to find.)

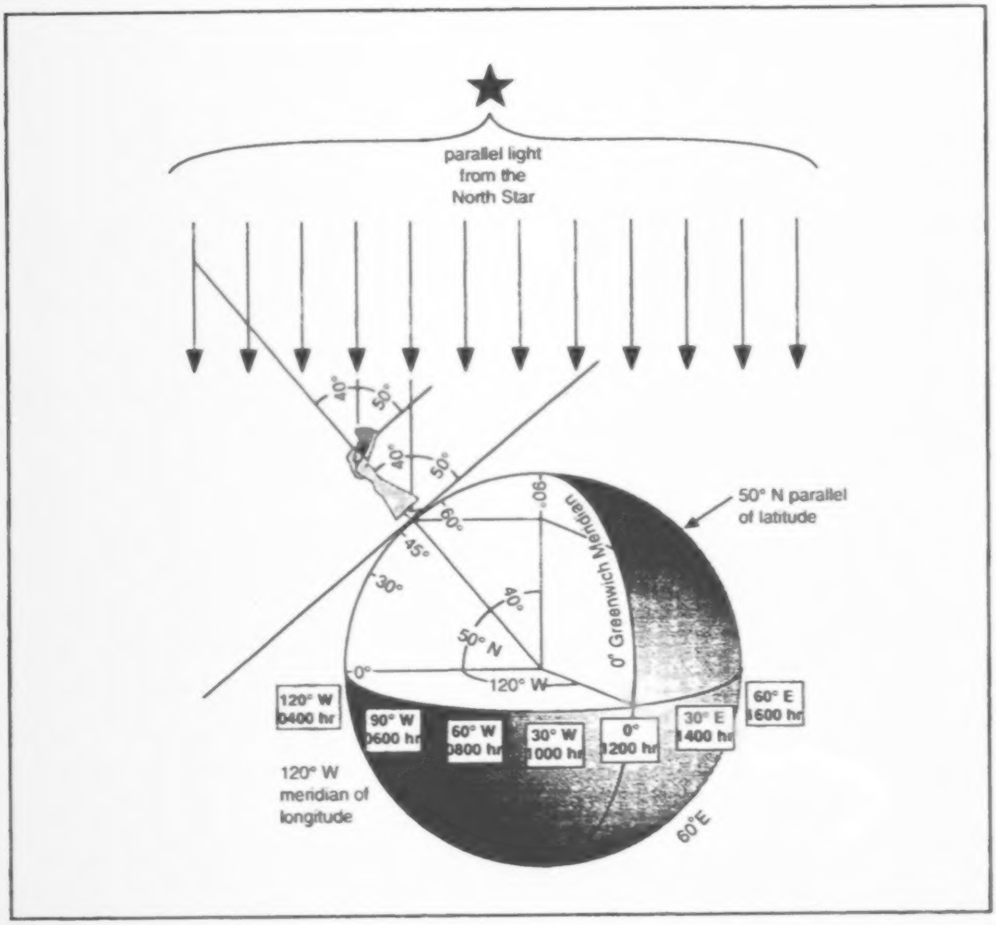
EXTENSIONS

Have the students

- Use an almanac to add other stars to their Planetarium.
- Find out what is meant by the magnitude (the brightness) of the stars.
- Make a magnitude or brightness scale.

  NOTE: In a rounded scale of magnitudes of brightness the sun has a magnitude of -27; the moon, -13; Venus, -4; Mars, -3; Mercury, -2; Sirius, -1; Vega, 0; Spica, +1; and Castor, +2. Each jump in the magnitude scale is about 2.5 times as great as the next value. Therefore, Venus at its brightest is 2.5 times as bright as Mars, which is about 2.5 times as bright as Mercury, and so forth.

ILLUSTRATIONS


parallel light
from the
North Star
40°
50°
40°
50°
60°
45°
30°
90°
0° Greenwich Meridian
50° N parallel
of latitude
40°
50° N
0°
120° W
120° W
0400 hr
90° W
0600 hr
60° W
0800 hr
30° W
1000 hr
0°
1200 hr
30° E
1400 hr
60° E
1600 hr
120° W
meridian of
longitude
60°E

The **latitude** of a location can be found by measuring the number of degrees the North Star (Polaris) is above the northern horizon. One degree above the horizon equals one degree of latitude. In the diagram an observer facing north finds the North Star to be five fists above the northern horizon. One fist equals 10°; five fists equal 50°. The observer is at 50° N latitude.

The **longitude** of a location can be found by measuring the difference between the time at the observer's location and the time at Greenwich. Times earlier than that at Greenwich are in the Western Hemisphere (W), and times later than that at Greenwich are in the Eastern Hemisphere (E). One degree of longitude is equal to 4 minutes of difference; 15° of longitude are equal to one hour of difference. In the diagram the time at the observer's location is 8 hours earlier than the time at Greenwich. The observer is at 120° W longitude.

Figure 5.7.3(1) Finding latitude and longitude

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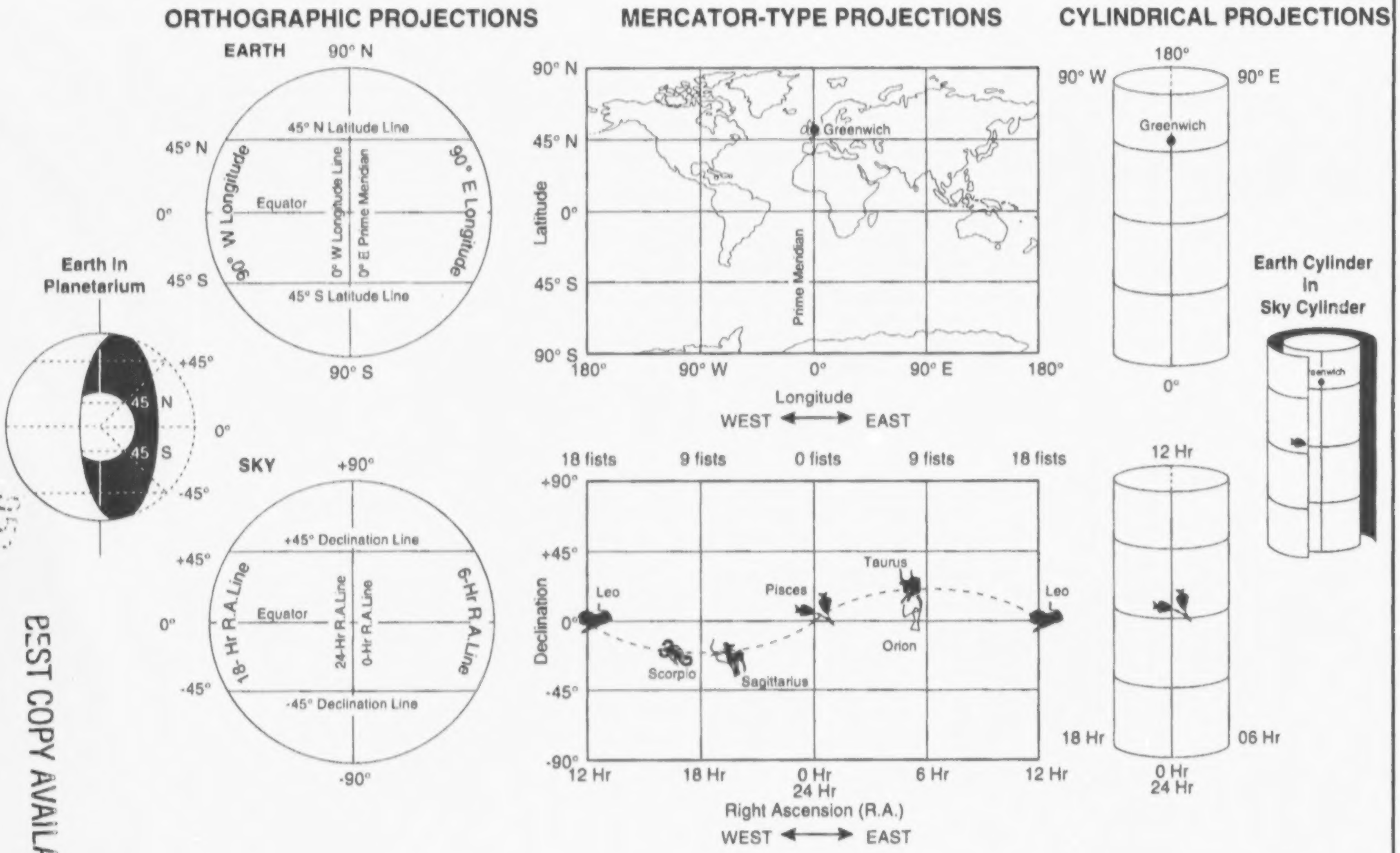
ORTHOGRAPHIC PROJECTIONS
MERCATOR-TYPE PROJECTIONS
CYLINDRICAL PROJECTIONS
EARTH
90° N
45° N
0°
45° S
90° S
45° N Latitude Line
45° S Latitude Line
Equator
90° W Longitude
90° E Longitude
0° W Longitude Line
0° E Prime Meridian
Earth In Planetarium
+45°
N
45
0°
45
S
-45°
SKY
+90°
+45°
-45°
-90°
+45° Declination Line
-45° Declination Line
18- Hr R.A.Line
24-Hr R.A.Line
0-Hr R.A.Line
6-Hr R.A.Line
Latitude
Greenwich
Prime Meridian
180°
90° W
0°
90° E
180°
Longitude
WEST ⟷ EAST
18 fists
9 fists
0 fists
9 fists
18 fists
Declination
Leo
Scorpio
Sagittarius
Pisces
Taurus
Orion
Leo
12 Hr
18 Hr
0 Hr 24 Hr
6 Hr
12 Hr
Right Ascension (R.A.)
WEST ⟷ EAST
180°
90° W
90° E
Greenwich
0°
Earth Cylinder In Sky Cylinder
Greenwich
12 Hr
18 Hr
06 Hr
0 Hr 24 Hr

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Figure 5.7.3(2) Five ways of viewing Earth and celestial coordinates comparing the relationship of latitude and longitude to declination and right ascension (R.A.)

DASH

Name____________________

Date____________________

STUDENT PAGE 5.7.3A MAPPING THE SKY

1. Assemble the model of Earth found in Figure SP 5.7.3A(1). *Cut* along the dark lines and *fold* along the dotted lines.

2. Cut out the center of the clock-face rings in Figures SP 5.7.3A(2–3). Color the interval between 0600 hours and 1800 hours *yellow* to indicate daylight. Glue the rings back to back with a sheet of plastic wrap sandwiched between. Trim off excess plastic wrap.

3. Explain how the longitude and latitude coordinates of Earth maps are similar to declination and right ascension (R.A.) coordinates on sky maps.

4. From its coordinates how do you find a star on the Planetarium, for example, a star with an R.A. of 11 hr 10 min and a declination of 57°?

Name ______________________________

5. **Explain how the *Barry's Wayfinding* doggerel can help find coordinates on Earth.**

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6. **Explain how the *Barry in Space* doggerel can help find coordinates in space.**

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Name ______________________

Date ______________________

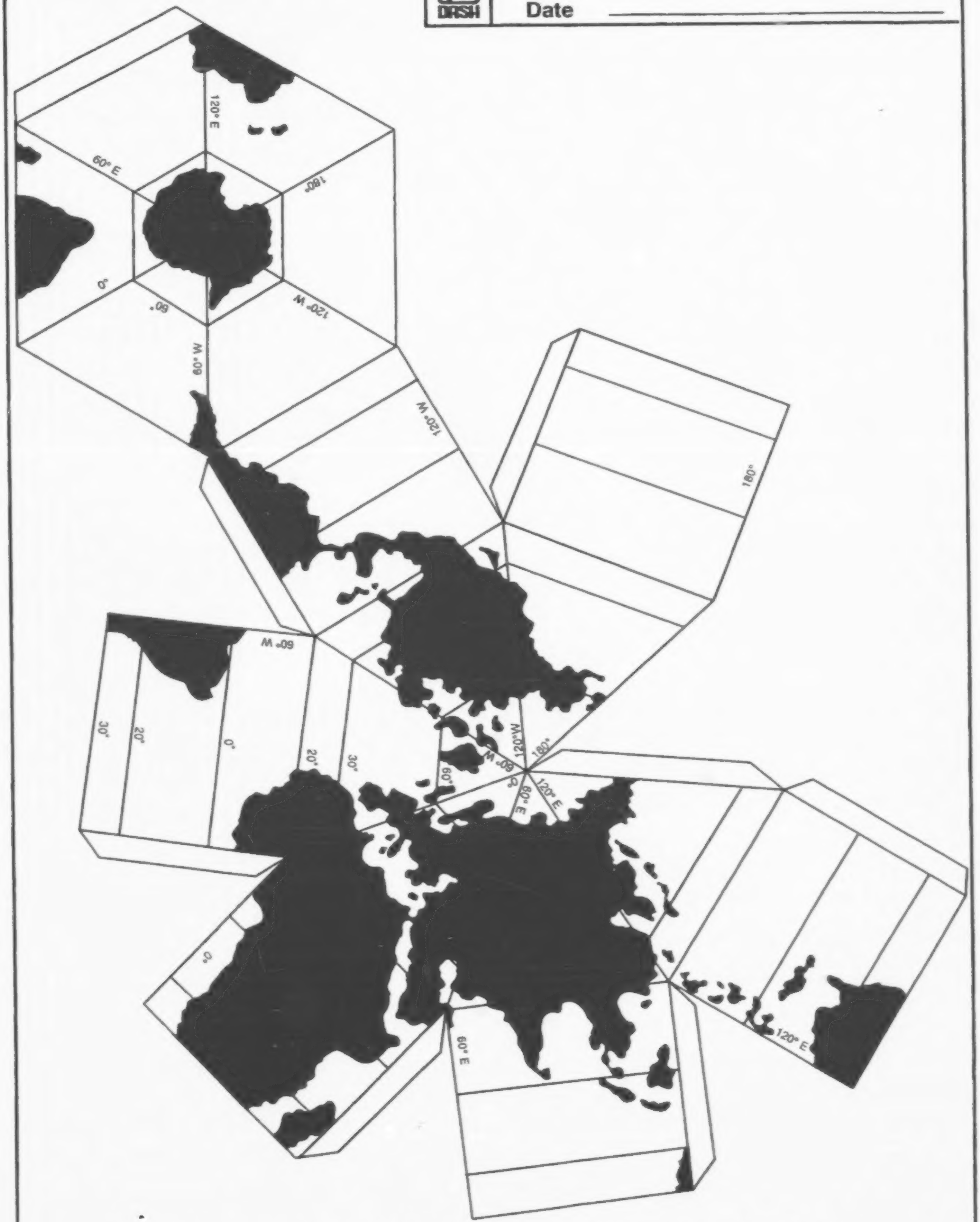

120° E
60° E
180°
0°
60°
120° W
60° W
120° W
180°
60° W
30°
20°
0°
20°
30°
120°W
180°
60° W
0°
60°
60° E
120° E
0°
60° E
120° E

Figure SP 5.7.3A(1) Model of the Earth showing latitude and longitude

Name ______________________________

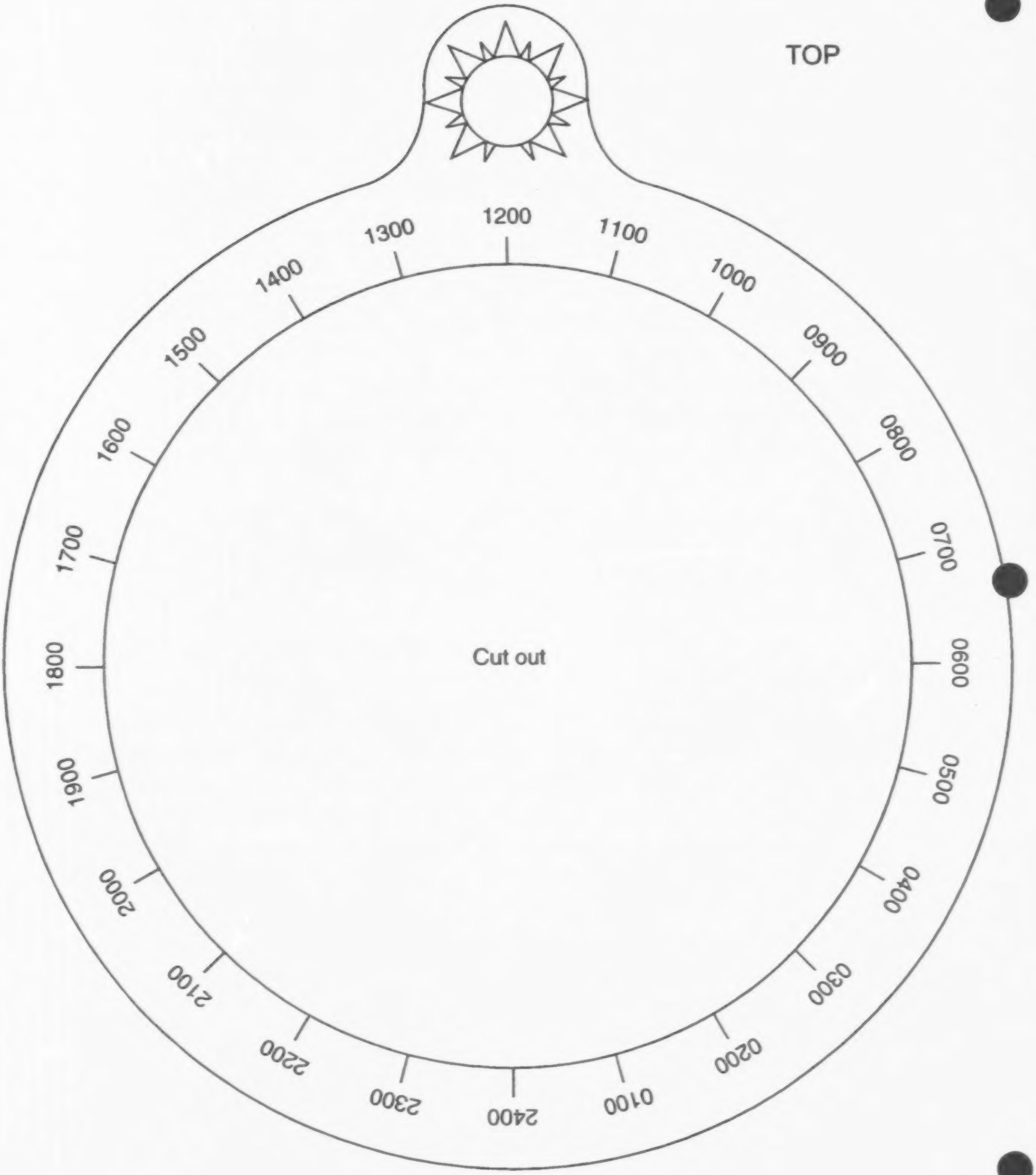

TOP
1200
1100
1000
0900
0800
0700
0600
0500
0400
0300
0200
0100
2400
2300
2200
2100
2000
1900
1800
1700
1600
1500
1400
1300
Cut out

Figure SP 5.7.3A(2) Top clock-face ring

Name ______________________________

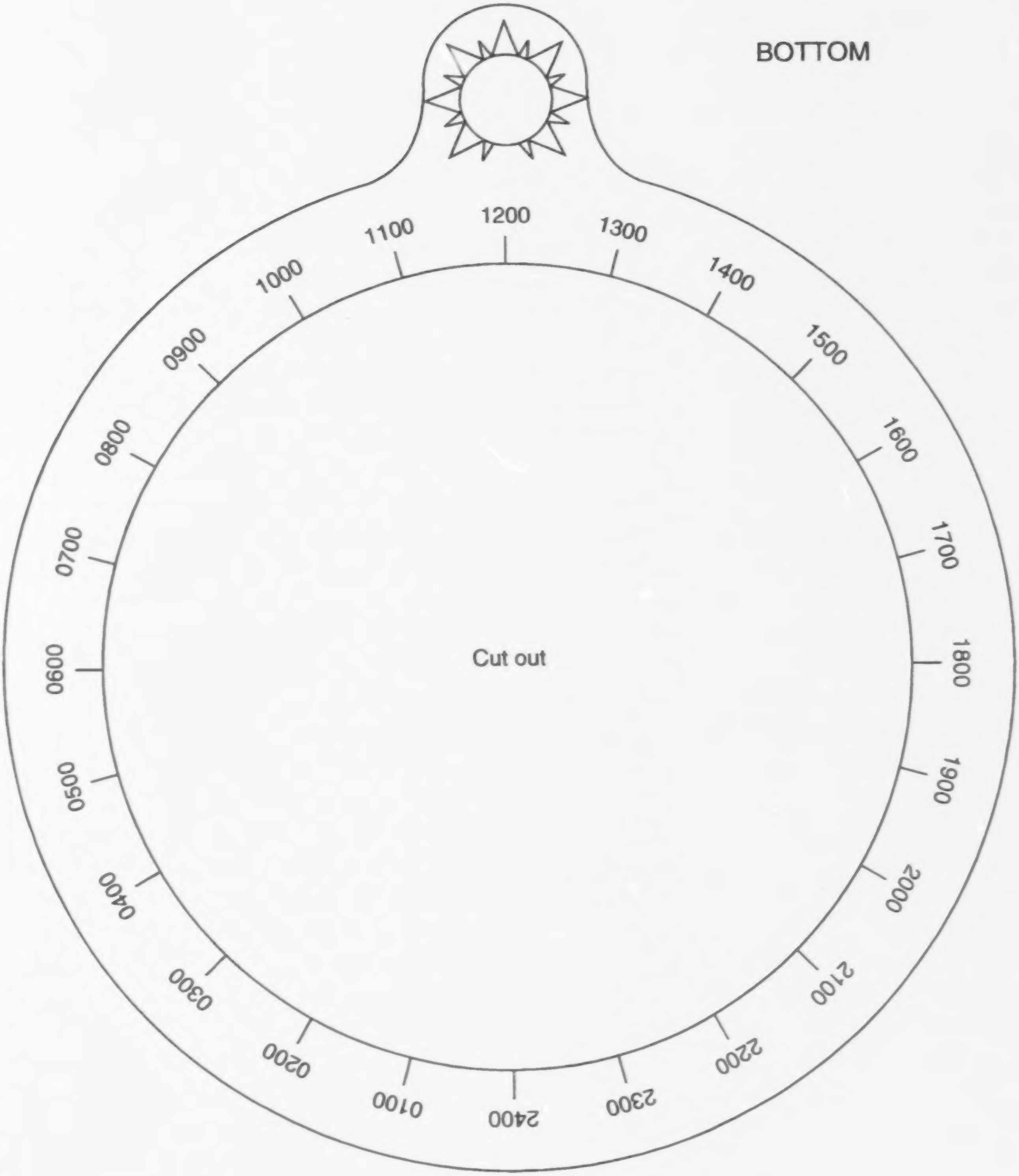

BOTTOM
1200
1300
1400
1500
1600
1700
1800
1900
2000
2100
2200
2300
2400
0100
0200
0300
0400
0500
0600
0700
0800
0900
1000
1100
Cut out

Figure SP 5.7.3A(3) Bottom clock-face ring

Name______________________________

Date______________________________

DASH

STUDENT PAGE 5.7.3B
BARRY'S WAYFINDING: LONGITUDE AND LATITUDE

BARRY'S WAYFINDING

There once was an explorer called Barry
Who a map refused to carry.
When he got lost,
A coin he'd toss,
But he'd wind up in places quite scary.

Coordinates he decided to learn
So he would always make the right turn.
The latitude line
Was easy to find
At night when he made a sojourn.

He would simply find the North Polar Star.
Then with his fists he'd measure how far
Above the horizon it lies
In the northern night skies.
Ten times his fists gave the latitude bar.

Longitude was no harder to find
For it he needed only Greenwich time.
For every degree
Is 4 minutes you see
Of difference from this prime time line.

His watch at Greenwich he'd set
At local noon the difference he'd get.
Dividing the minutes by 4,
He'd shout with a roar
The longitude so he wouldn't forget.

Now there's a lesson in this
And it's one that is hard to resist.
When the North Star's height
And Greenwich time unite
On Earth you'll always know where you exist.

Name________________________

Date________________________

DASH

STUDENT PAGE 5.7.3C
BARRY IN SPACE: DECLINATION AND RIGHT ASCENSION

BARRY IN SPACE

Oh, Barry got hooked on the stars
And decided to take a group up to Mars,
But how would they find
A place of this kind
When in space in their long rocket cars?

A map of the heavens Barry found
And he spread it out on the ground.
"Aha!" he said.
"This is easily read.
It's like all the other maps around.

"Look, like Earth, it's got an equator
And Polaris' 90° is our orientater.
Declination we'll find
On the meridian line
And use our fist as a degree calculator.

"For example, let's take a star that's bright.
Betelgeuse is brilliant at night.
Plus 10° its declination
Six hours its right ascension
Are the coordinates that we will write.

"Now, each fist from the Pole Star dot
Is 10 degrees from 90 on the declination plot.
Eight fists down
What have we found?
Heaven's equator is 10 degrees from the spot.

Name ______________________________

"We can see from this simple operation
What I mean by the similar relation.
How finding magnitude
Of our Earth's latitude
Is like finding the heavens' declination.

"That leads us to our right ascension.
Finding that's almost too easy to mention.
Twenty-four hours it will take
For the heavens to make
A full circle by Ptolemaic convention.

"Here on the heavens' equator line
We look for the sixth hour of time,
And at the intersect,
As we would expect,
Betelgeuse is right there to find.

"To use the great circle of the equator
There is a natural space locator.
Between hours 5 and 6
We get our R.A. fix.
On Orion's Belt there's a three-star indicator."

"We're all ready to go," said Barry.
"Only a map and our fists we need carry.
An almanac too
Will give us a cue,
And finding Mars will never be scary."

ACTIVITY 5.7.4
NORTH POLE, EQUATOR, AND ECLIPTIC

OBJECTIVES

The students
- Relate the length of gnomon shadows to apparent north-south changes the sun's position.
- Relate the declination of the sun to the gnomon angle at the equator.
- Find the path of the sun through the Zodiacal Band.
- Identify the ecliptic of the sun.

BACKGROUND

This activity is one of a series about location. It should follow Activities 5.2.6 GNOMON, 5.7.1 WHERE IN THE WORLD ARE WE? 5.7.2 PLANETARIUM, 5.7.3 MAPPING THE SKY, and 5.2.5 TRIANGLES. It should be followed by 5.2.11 MODELS OF THE SOLAR SYSTEM and 5.7.5 WHERE IS EARTH?

Approach

The students first use a flashlight or overhead projector to demonstrate their understanding of how the sun produced the gnomon data collected in Activity 5.2.6 GNOMON. They then find the shadow triangle produced when the gnomon intercepts the light from the sun and identify the *gnomon angle* in the part of the shadow at the top of the gnomon. Next, they simulate gnomon-angle readings at their school, the Tropics of Cancer and Capricorn, and the equator at the time of the equinoxes and the solstices. For their simulation they use miniature gnomons attached to a globe.

Finally, the students relate gnomon data taken at Singapore, which is on the equator, to the changing declination of the sun throughout a year. This shows the apparent north-south movement of the sun. With these data they trace the sun's declination month by month on their Planetarium. They find that the sun seems to follow a path called the *ecliptic* through the Zodiacal Band.

Gnomon

A gnomon is a shaft such as a stake, pole, nail, and so forth that is perpendicular to the Earth's surface and can be bathed in sunlight. The gnomon shaft is on an imaginary straight line that starts at Earth's center and extends into the endless space above it. In a model of Earth within a

Planetarium this imaginary line is seen to follow a circle of declination on the inner surface of the Planetarium as the Earth turns. See Figure 5.7.4(1). This circle of declination is the same number of degrees from the celestial equator as the gnomon's latitude is from Earth's equator. For example, a gnomon at latitude 45° N is in line with a +45° circle of declination above it. The imaginary line extending from a gnomon on the equator follows the celestial equator on the Planetarium.

Student Demonstration

It is suggested that the gnomon simulations (Procedures 1–3) be demonstrated by one or two small groups of students. The operations called for in the demonstration require practice to show clear results.

Flashlight "Sun" (Procedure 1)

The rays of the sun that strike Earth are nearly parallel to each other. Because of the great distance between Earth and the sun, only a very small tube of its light reaches Earth. To simulate parallel rays of sunlight, a paper tube can be put over the end of a flashlight to select the more nearly parallel rays. See Figure 5.7.1(2). Though the longer the tube the more nearly parallel the light rays will be, a sheet of notebook paper usually makes a satisfactory tube.

Flashlight "Sun" and Class Gnomon

Figure 5.7.4(2) shows the shadow made by a flashlight shining on a class gnomon. The students should note that the gnomon shadows made by the flashlight are about the same as the gnomon shadows made by the sun. By using a flashlight for the sun and a screen they can also find a shadow triangle next to the gnomon.

Globe with Gnomons (Procedure 2)

Have the students attach nail gnomons to a globe as shown in Figure 5.7.4(3). Have them use the term *noon* to refer to *local noon*—the time when the sun is on the meridian, the imaginary north-south great circle that passes directly overhead.

"Sun" and Globe Gnomons

A gnomon directly below the sun at noon makes no shadow. This means that when simulating the sun with a flashlight the barrel must be lined up with the shaft of the gnomon. The student holding the flashlight can make sure that the barrel is aligned north and south. A second student can check from the side to see that the barrel is aligned with the center of the globe. Have the students use a flashlight with a large beam.

If a projector is used as a simulated sun, be sure that the center of the beam is lined up with the gnomon. It is best to use the globe some distance from any projector.

Sun's Shadow at the Equinoxes and Solstices (Procedure 3)

Singapore is on the equator at 0° latitude and is always under the celestial equator. At noon on the days of the spring and fall equinoxes the sun is directly over Singapore and a gnomon makes no shadow. See Figures 5.7.4(4) and SP 5.7.4(1). At other gnomons at other latitudes there is a noon shadow on the day of the equinox. In the diagrams these shadows are shown on card screens placed next to the gnomons.

On the day of the Northern Hemisphere's *winter solstice* (on or about December 21) there is no shadow at noon on gnomons at latitude 23° S. As we would expect, the sun at noon is directly over gnomons at latitude 23° S on that date, and the sun's declination is -23°. See Figures 5.7.4(5) and SP 5.7.4(1). Again, at every other gnomon at other latitudes there is a noon shadow at the winter solstice.

On the day of the Northern Hemisphere's *summer solstice* (on or about June 21) there is no shadow at noon on gnomons at latitude 23° N. At noon the sun is directly over these gnomons. On that date the sun's declination is +23°. See Figures 5.7.4(5) and SP 5.7.4(1).

Latitude and Sun's Shadow at the Equinoxes

If we look at Figure 5.7.4(4) and Figure SP 5.7.4(1), we can see that at the equinoxes the *gnomon angle,* which is the upper angle of the shadow on the card-screen, is equal in degrees to the latitude of the gnomon. For example, the gnomon angle at the Tropic of Cancer (23° N latitude) is 23° at noon on the equinox. Similarly, the gnomon angle at latitude 45° N is 45° and the gnomon angle at 23° S is 23° at noon on the equinox. We can find our latitude anywhere on Earth at the equinox by using a gnomon.

Reading the Sun's Declination at Singapore

The gnomon angle at noon on the equator, for example at Singapore, gives the declination of the sun. When the sun is over the Tropic of Cancer (latitude 23° N) at noon at the time of the Northern Hemisphere's summer solstice, the gnomon angle is about 23° at the equator. When the sun is over Tropic of Capricorn (latitude 23° S) at noon on the day of the winter solstice, the gnomon angle is 23° at the equator. At the equator the gnomon angle is always numerically equal to the declination of the sun. Thus, a gnomon at Singapore can be used to measure the declination of the sun throughout the year. See SP 5.7.4(2) where the declination of the sun is graphed.

School's Noon Gnomon Angles

The students can find the upper angle in the noon gnomon shadow (the *gnomon angle)* several ways. First, they can put a screen in the shadow made by their gnomon and measure the angle. Second, they can run a straight edge from the tip of their gnomon to the end of the noon shadow-line on their record sheet and measure the angle. Other techniques can be invented by the students.

Finding the Ecliptic

The position of any heavenly body can be found by its right ascension (R.A.) and declination coordinates. The declination of the sun can be found from gnomon data taken at Singapore on the equator. The R.A. of the sun can be found from its position among the zodiacal constellations. Each of the zodiacal constellations is spread across several hours of right ascension. For example, Pisces is spread from about R.A. 23 hr to R.A. 2 hr. The sun is in Pisces at the spring equinox. Knowing the approximate R.A. and the declination 0° degrees at the spring equinox, we can find the approximate location of the sun as it appears on the Planetarium.

Using a Planetarium and these declinations and approximate R.A.s, the students will find that the sun's north-south movement follows a line called the *ecliptic,* a term you will probably need to supply. Further description of the ecliptic follows in Activities 5.2.11 MODELS OF THE SOLAR SYSTEM and 5.7.5 WHERE IS EARTH?

Extension

The students can follow the apparent movement of the sun at their school by graphing the length of their noon gnomon lines. These shadow lines follow the same undulating path as the graph of declination at Singapore.

STUDENT ROLE

Astronomer

MATERIALS

roofing nails, 1 in or longer
Post-its
flashlight or overhead projector
3 x 5-in index cards
scissors
protractor
tacky clay to hold miniature gnomons on globes
globes
gnomon and gnomon data from Activity 5.2.6 GNOMON
Planetariums from Student Pages 5.7.2 (A–B)
Student Page 5.7.4 NORTH POLE, EQUATOR, AND ECLIPTIC

PRODUCTS

Completed Student Pages

PROCEDURES

1. **Indicate to the students that we have found by using gnomons that the sun appears to move north and south over the seasons and now we need to find the path it seems to take in the sky. Help a demonstration team to use the class gnomon data and a flashlight to analyze the north-south movement of the sun. See Figure 5.74(2).**

   Ask such questions as these:
   - What do we know about the sun's local-noon shadow line? (Get at such things as local noon is the time of the shortest shadow of the day, at that time the shadow points to the North Pole, at that time the sun is halfway across the sky and directly overhead, and so forth.)
   - Can we use a flashlight to represent the sun and line up our gnomon so that its shadow is on top of our last noon-shadow line? (Have a student orient the flashlight. See Figure 5.7.4[2].)
   - Where is the flashlight's position compared to the sun's position when it made the noon-shadow line? (Have the students note that the flashlight is lined up about the same way as the sun was when it made the original shadow line—the flashlight is on the north-south line.)
   - Where is the flashlight when it casts shadows along the shadow line made by the sun in the morning? (Have a student orient the

flashlight and observe that the west-directed shadow is formed when the flashlight is in about the same position as the sun was in when it made the morning shadow.)

- Can anyone use the flashlight to show us how the local-noon shadow line changes over the year? (Have students demonstrate the way the length of the shadow changes as the flashlight moves north and south. See Figure 5.7.4[2].)
- Where would the flashlight sun be at the beginning of winter or December 21? (Work for agreement that it would be at the extreme end of its southern movement.)
- Where would the flashlight sun probably have to be to get the shadow we have today? (It would be north of the winter solstice position.)

2. **Help student demonstrators place four miniature gnomons on a globe to allow investigation of the sun's shadows at different latitudes. See Figure 5.7.4(3).**

Help the students

- Cut a 3 x 5-in index card in quarters.
- Make four miniature gnomons by pushing a long roofing nail through the middle of each card.
- Put a dab of tacky clay on the bottom of the nails and place them on a globe so they are perpendicular to its surface.
- Place the gnomons at latitudes 23° S, 23° N, 0° (the equator), and at the latitude of their school. Place them all on the same longitude line as the school so they are in north-south alignment.
- Demonstrate to the class how they have attached the gnomons to the globe.

3. **Have the students demonstrate using a flashlight or projector to investigate gnomon shadows when the sun is at different declinations. Have them hold the flashlight so that the entire barrel is in vertical alignment with any desired spot on Earth's surface. See Background.**

Ask such questions as

- What is the shadow of a gnomon like when the flashlight beam comes from directly overhead? (Work to the observation that there is no shadow.)
- What time of day would this occur? (Work to observation that it would occur at local noon.)

- Does the sun ever pass directly over our school? (For students living close to the equator, between 23° north and south of the equator the answer will be yes, for others no. If the students are not sure of the answer, ask the question after they have used the Singapore gnomon data.)
- Where do the noon-shadow lines of the four gnomons point when the flashlight is directly above the gnomon at the equator? (Work to the observation that the noon-shadow line of the gnomon at 23° S points south, at 23° N it points north, and at schools in the Northern Hemisphere (above the equator) it points north. There is no shadow line at the equator.)
- What are the gnomon angles at 23° S, 23° N, and the school when the flashlight is directly above the equator? (Work to the observation that the shadow angle found on a card screen is 23° at the 23° N and 23° S latitudes. The shadow angle at their school is the same as the latitude of the school. It is 0° at the equator. See Figures 5.7.4[4] and SP 5.7.4[1]. Introduce the use of card screen to capture the angle.)
- How could we use our class gnomon to find our latitude? (Get at the idea that when the sun is above the equator at the equinox, we can get our latitude at noon directly from our gnomon angle.)
- What is the shadow like as the flashlight beam moves north and south? (Have the students explore the movement of the beam, keeping the barrel of the flashlight in vertical alignment with the center of the globe. See Background. Work for agreement that the movement of the shadow is like the movement of the sun through the year.)
- Is there a position where the flashlight makes no shadow with gnomons at 23° N latitude and at 23° S latitude? (Work to the observation that there is no shadow when the flashlight is directly over the gnomons. See Figures 5.7.4[5]) and SP 5.7.4[1].)

4. **Help the students locate the ecliptic on their Planetarium using the graph of 1991 gnomon data taken in Singapore (latitude 0°). Have them use Figures SP 5.7.4(1–2).**

Ask such questions as

- What do we mean by the angle of declination of a heavenly body? (Review the definition from Activity 5.7.3 MAPPING THE SKY. *Declination* is the measure of the number of degrees a star or other heavenly body is above [+] or below[-] the celestial equator.)

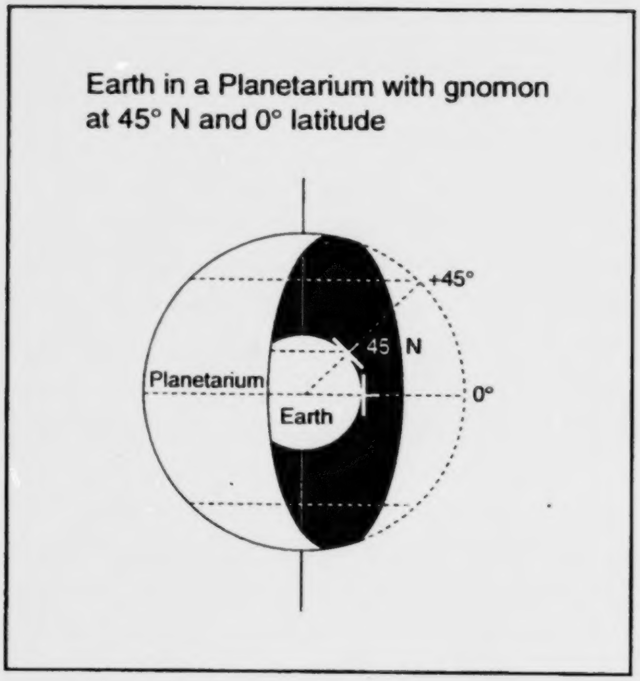
- How is declination related to latitude? (Review, noting that latitude is like declination. *Latitude* is the measure in degrees on Earth on a north-south line above or below the equator. A heavenly body with a declination of +23° will appear to continually circle over latitude 23° N.)
- Where is the angle of declination of the sun shown on the gnomon's shadow triangle in the three diagrams of Figure SP 5.7.4(1)? (Help the students demonstrate that the upper angle of the shadow triangle at the equator (the location of Singapore) is the same as the angle of declination of the sun. For example, when the sun is above the gnomon at 23° S, its declination is -23° and the upper angle of the shadow triangle at the equator is 23°. When the sun is above the gnomon at 23° N, its declination is +23° and the upper angle of the shadow triangle at the equator is 23°.)
- On the graph of the sun's declination at Singapore shown in Figure SP 5.7.4(2) what is the declination of the sun in its apparent southernmost movement? (This will be about -23°.)
- On what date does the sun have this declination? (About December 21.)
- In what constellation is the sun around December 21? (Help the students identify Sagittarius on their Planetarium and place a Post-it in Sagittarius on declination -23°.)
- What is another name for the solar events of December 21? (We call this the winter solstice when we have the longest night of the year in the Northern Hemisphere below the Arctic circle.)
- On the graph shown in Figure SP 5.7.4(2) what is the declination of the sun in its apparent northernmost movement? (This will be about +23°.)
- What is the date when the sun has this declination? (June 21.)
- What is another name for the solar events of June 21? (This is the *summer solstice,* when we have the longest day of the year in the Northern Hemisphere below the Arctic Circle.)
- What constellation is the sun in on June 21? (Help the students identify Gemini on their Planetarium and place a Post-it circle on declination +23°.)
- On the graph of the sun's declination at Singapore, when is the declination of the sun 0°? (March 21 and September 23.)
- What do we call the solar events of March 21 and September 23? (The *equinoxes,* when day and night are of equal length.)
- What constellations is the sun in on March 21 and September 23? (Help the students identify Pisces [March 21] and Virgo [September 23] on their Planetarium and place a Post-it circle on declination 0°. See Figure 5.7.4[6].)

- Does anyone find a line on the Planetarium that these points fall upon or are very near? (Help the students find the ecliptic.)
- Does anyone know what this line is called? (It is the *ecliptic*. Have the students record a definition of the term in their Working Dictionary. Capture the idea of the apparent path of the sun through the Zodiacal Band.)

EXTENSION

- Help the students invent a demonstration using their own gnomon data to show how the sun appears to travel through the heavens. One technique is to graph the length of their noon gnomon shadows and compare the shape with a graph of Singapore data.

ILLUSTRATIONS



Earth in a Planetarium with gnomon at 45° N and 0° latitude

Figure 5.7.4(1) Model of Earth in a spherical Planetarium with imaginary lines extending from Earth's center through the shafts of gnomons into space where they follow along circles of declination as Earth turns. For example, an imaginary line through a gnomon at 45° N latitude is shown following along the +45° circle of declination and another at Earth's equator is shown following the celestial equator.

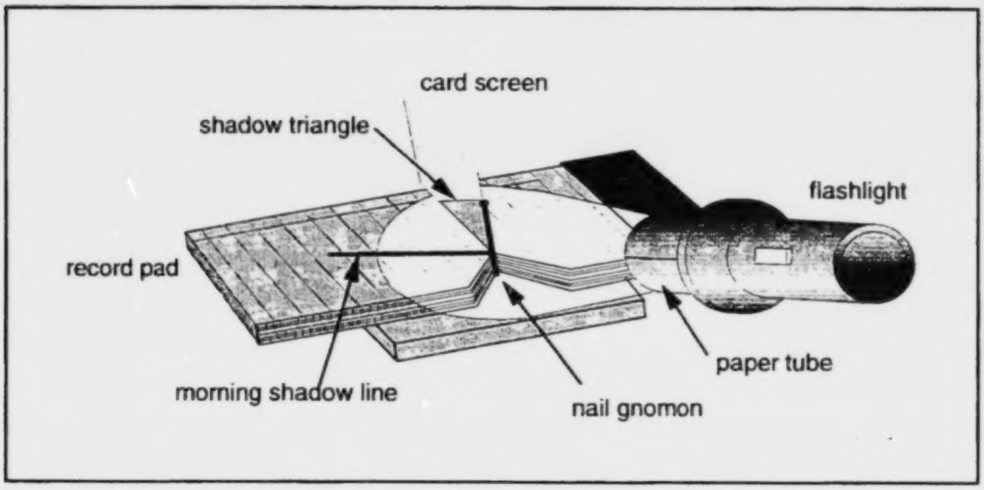

card screen
shadow triangle
flashlight
record pad
paper tube
morning shadow line
nail gnomon

Figure 5.7.4(2) Simulating the gnomon record using the class gnomon, the gnomon record pad, and a flashlight. Also showing the shadow triangle made on a card-screen.

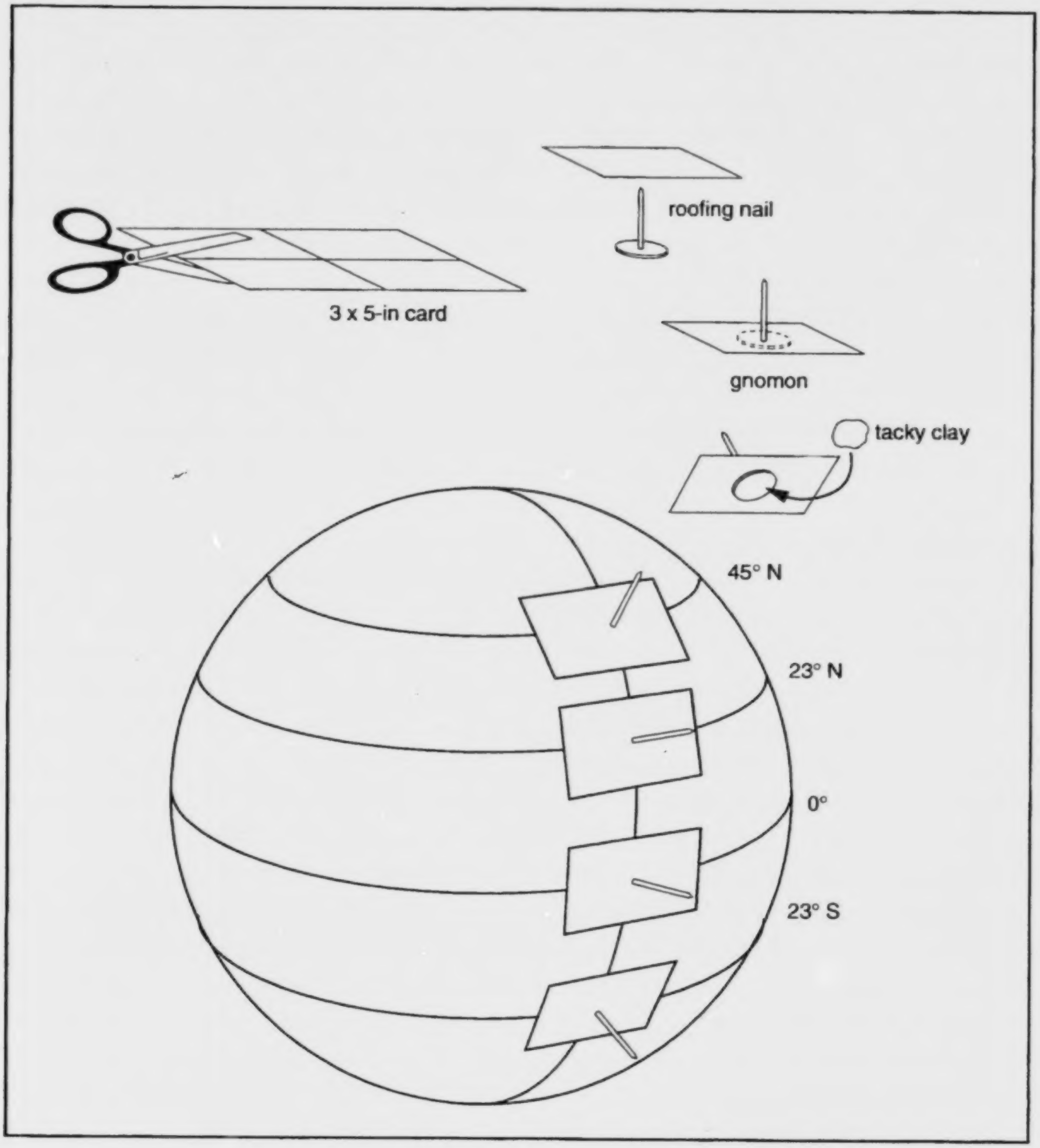

roofing nail
3 x 5-in card
gnomon
tacky clay
45° N
23° N
0°
23° S

Figure 5.7.4(3) Making miniature gnomons and attaching them to a globe at latitudes 23° S, 23° N, 0°, and the latitude of a representative school at 45° N

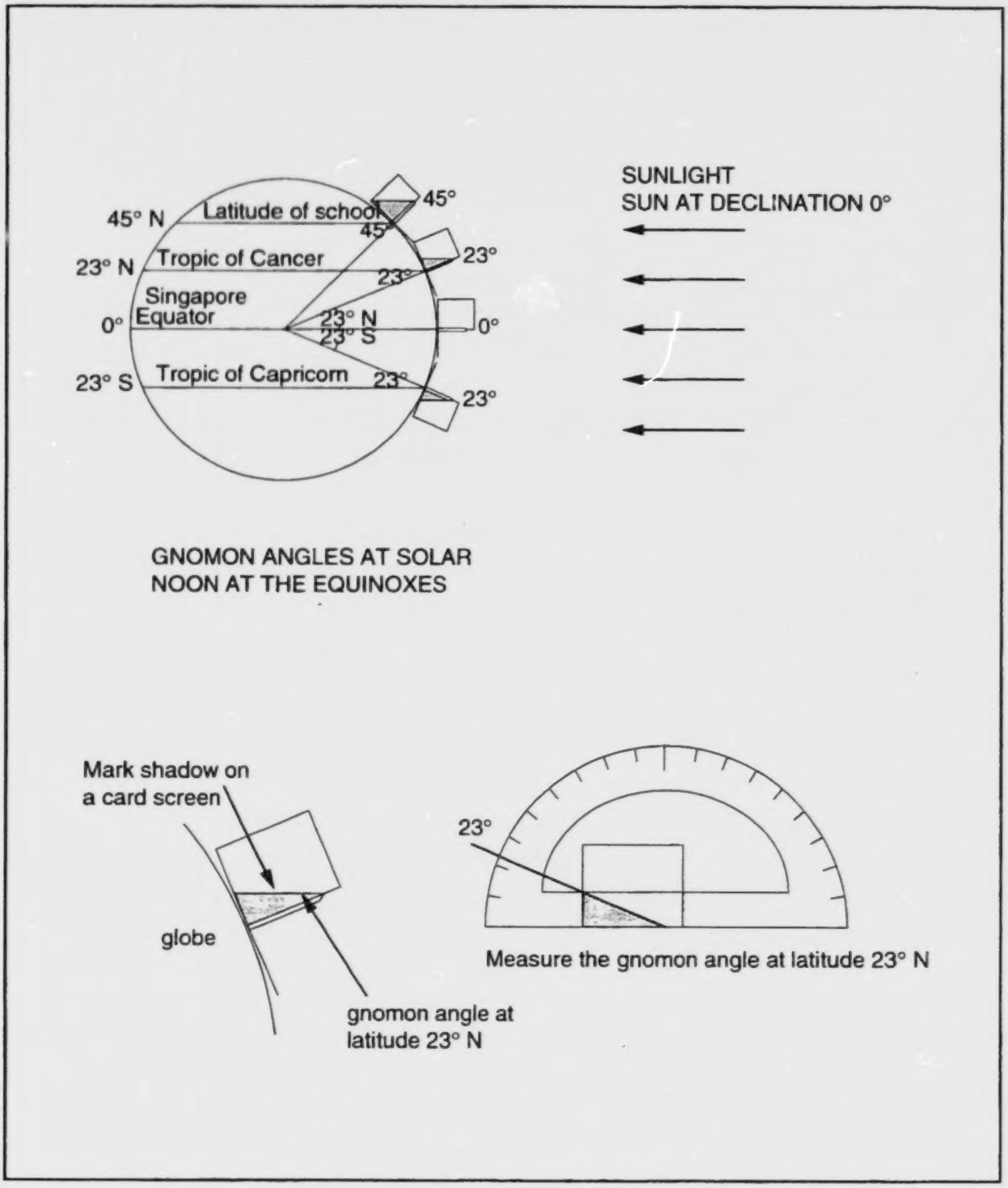
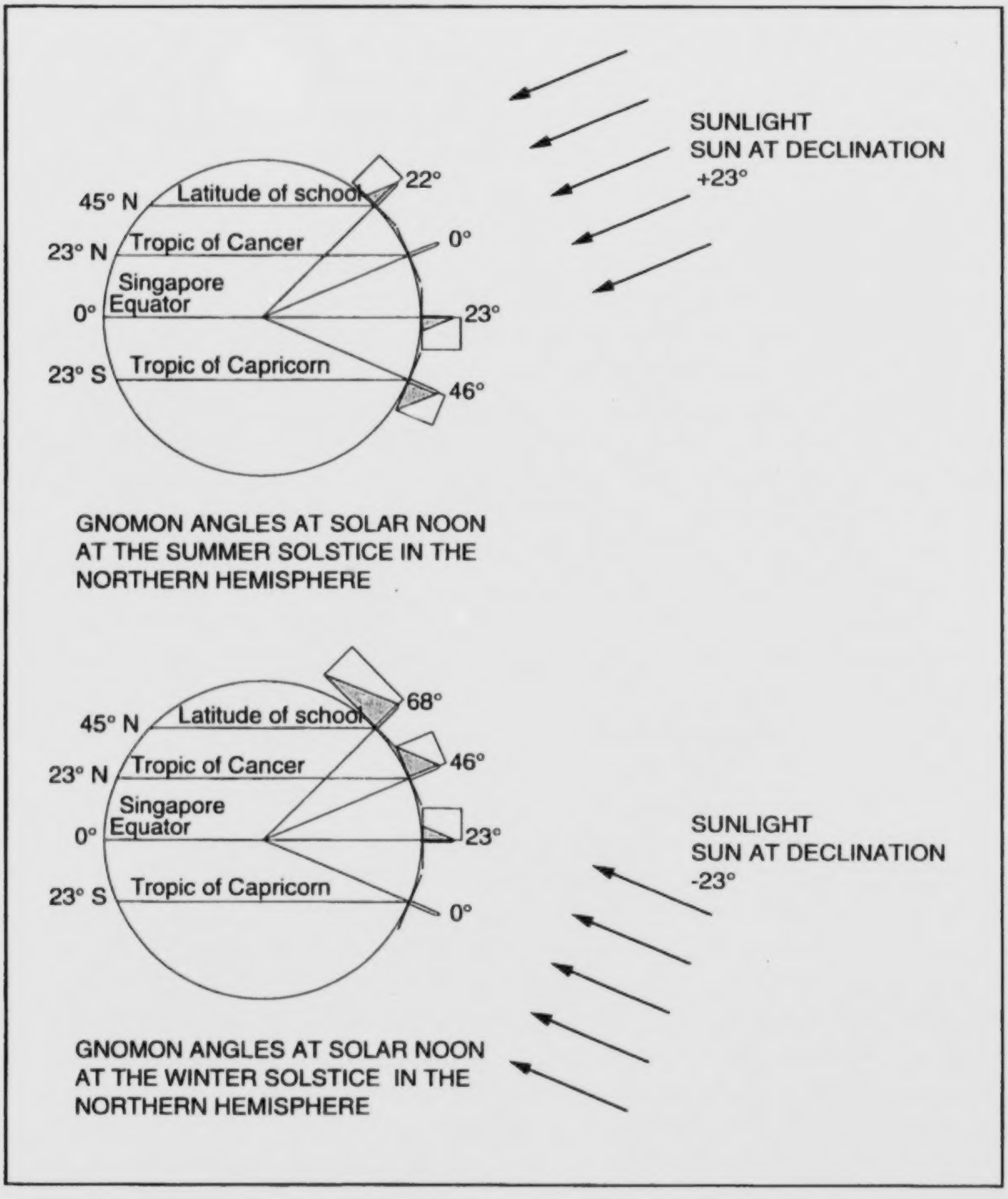

SUNLIGHT
SUN AT DECLINATION 0°
45° N
Latitude of school
45°
45°
23° N
Tropic of Cancer
23°
23°
Singapore
0°
Equator
23° N
23° S
0°
23° S
Tropic of Capricorn
23°
23°
GNOMON ANGLES AT SOLAR NOON AT THE EQUINOXES
Mark shadow on a card screen
globe
gnomon angle at latitude 23° N
23°
Measure the gnomon angle at latitude 23° N

Figure 5.7.4(4) Technique for measuring gnomon angles. Angles are made visible when the gnomon shadow falls on a card screen. Shown are gnomon angles at the equinoxes.


SUNLIGHT
SUN AT DECLINATION
+23°
22°
45° N
Latitude of school
23° N
Tropic of Cancer
0°
Singapore
Equator
0°
23°
23° S
Tropic of Capricorn
46°
68°
45° N
Latitude of school
46°
23° N
Tropic of Cancer
Singapore
Equator
0°
23°
SUNLIGHT
SUN AT DECLINATION
-23°
23° S
Tropic of Capricorn
0°

GNOMON ANGLES AT SOLAR NOON AT THE SUMMER SOLSTICE IN THE NORTHERN HEMISPHERE

GNOMON ANGLES AT SOLAR NOON AT THE WINTER SOLSTICE IN THE NORTHERN HEMISPHERE

Figure 5.7.4(5) Gnomon angles produced by a flashlight and gnomons attached to a globe simulating sunlight at the solstices

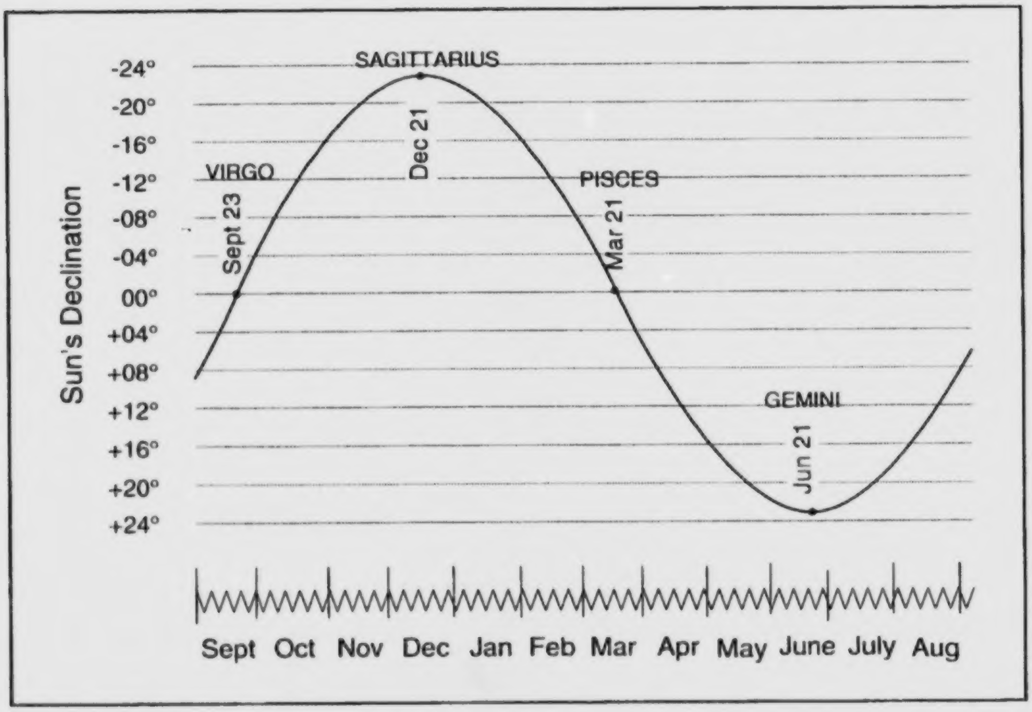


Figure 5.7.4(6) Graph of a gnomon's local noon shadows at Singapore over a 12-month period. Recorded in degrees of declination. Also showing the constellations the sun is in on the dates shown.

DASH

Name____________________

Date____________________

STUDENT PAGE 5.7.4
NORTH POLE, EQUATOR, AND ECLIPTIC

1. Describe your demonstration of how a flashlight or overhead projector can be used to show the changing noon gnomon readings. Use diagrams as needed.

2. Figure SP 5.7.4(1) is a diagram showing three gnomons—one at Singapore, which is at 0° latitude, one at 23° N, and one at 23° S. You are looking east and the time is 1200 hours, solar noon. Shadow triangles produced at the time of the equinoxes and solstices are shown. Explain how the declination of the sun can be read directly from the gnomon angle at Singapore. Use diagrams as needed.

Name ______________________________

3. Explain how the Singapore gnomon data on the graph in Figure SP 5.7.4(2) helps us trace the path of the sun through the Zodiacal Band.

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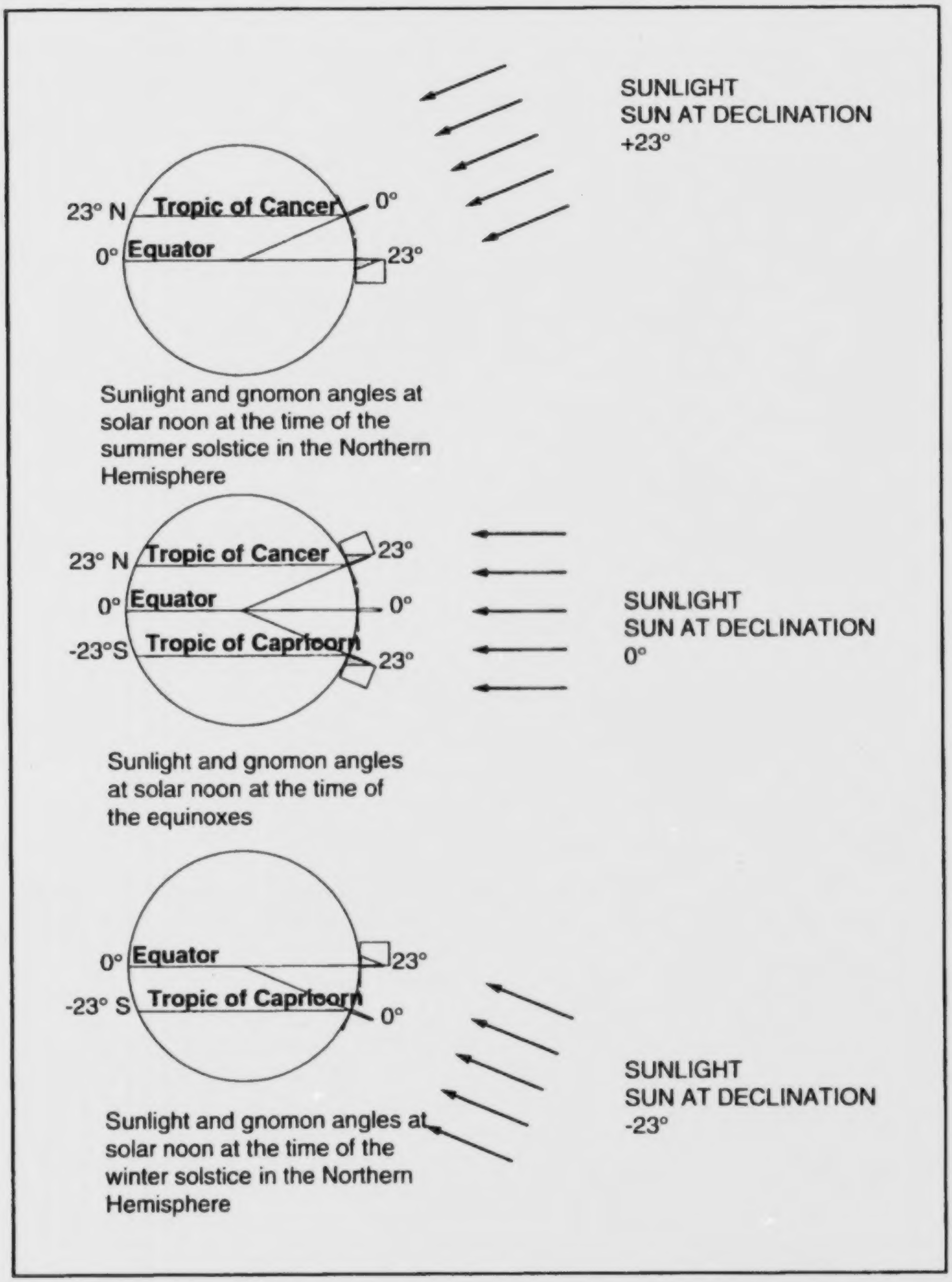
ILLUSTRATIONS

Name ______________________________


SUNLIGHT
SUN AT DECLINATION
+23°
23° N
Tropic of Cancer
0°
0°
Equator
23°
23° N
Tropic of Cancer
23°
0°
Equator
0°
-23°S
Tropic of Capricorn
23°
SUNLIGHT
SUN AT DECLINATION
0°
0°
Equator
23°
-23° S
Tropic of Capricorn
0°
SUNLIGHT
SUN AT DECLINATION
-23°

Sunlight and gnomon angles at solar noon at the time of the summer solstice in the Northern Hemisphere

Sunlight and gnomon angles at solar noon at the time of the equinoxes

Sunlight and gnomon angles at solar noon at the time of the winter solstice in the Northern Hemisphere

Figure SP 5.7.4(1) Sunlight on gnomons at 23° N, the equator (0°), and 23° S at solar noon at the solstices and equinoxes

Name ______________________________

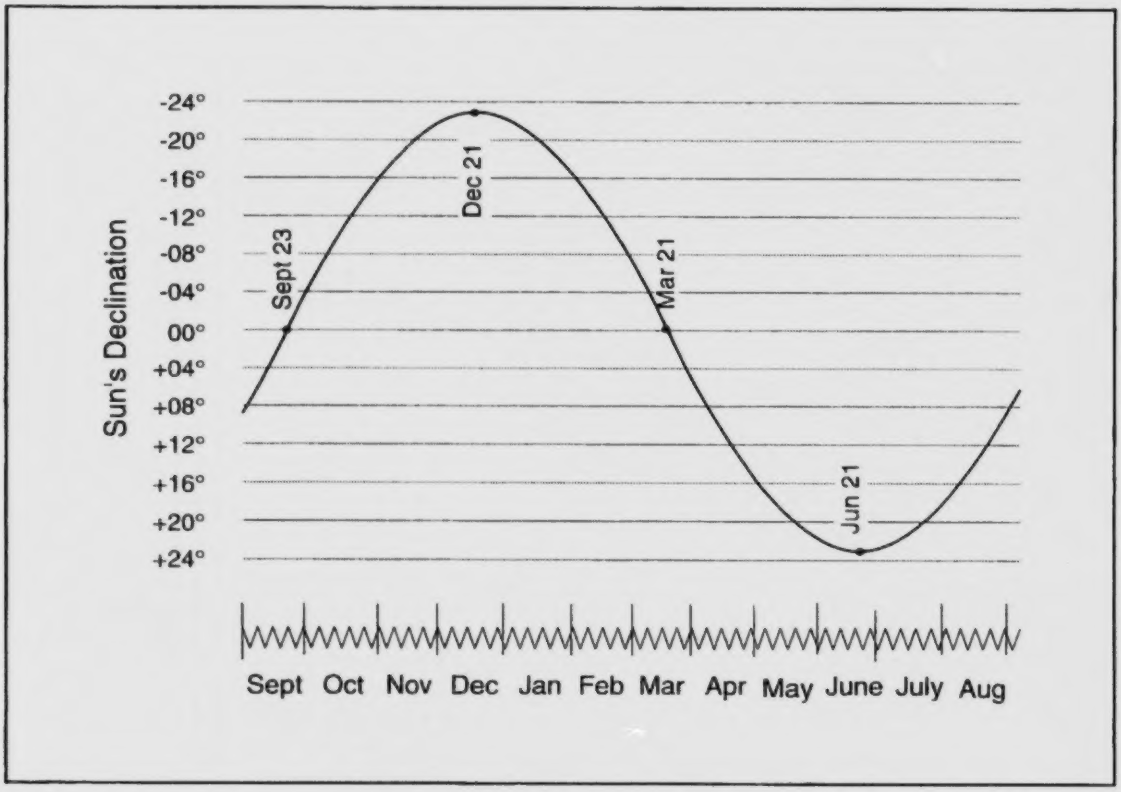


Figure SP 5.7.4(2) Graph of a gnomon's local noon shadows at Singapore over a 12-month period. Recorded in degrees of declination.

ACTIVITY 5.7.5 WHERE IS EARTH?

OBJECTIVES

The students
- Make models of Earth and its orbit around the sun.
- Identify the direction of rotation and revolution of Earth in relation to its north pole.
- Identify the zodiacal constellations in the night sky during different seasons.
- Make a model to demonstrate the ecliptic and the seasonal change in lighting.

BACKGROUND

This is the last of the series of activities on astronomy. It should follow Activity 5.2.11 MODELS OF THE SOLAR SYSTEM. The students should now be ready to look at the path of Earth around the sun and see how it is oriented with the stars. WHERE IS EARTH? is carried out using models produced by the students.

Earth's Rotation and Revolution

To explore the direction of rotation and revolution of Earth, the students make a model in which the sun is represented by a pushpin, gravity by a paper clip, Earth by a pencil, and the Zodiacal Band by the drawings in Figures SP 5.7.5(2–3). The view plane of an observer is represented by a small square of paper pasted on the side of the pencil. Compass points N, S, E, and W are marked on the view plane. See Figure SP 5.7.5(1). Using the point of the pencil as the South Pole, the students trace the orbit of Earth around the sun. They find that Earth rotates counterclockwise in relation to the North Pole and Earth revolves counterclockwise around the sun. Finally, they describe what the night sky will look like at different dates.

Plane of the Ecliptic

The students then make a coat-hanger model to simulate Earth's orbit and the tilt of its axis. This model is used along with the Planetarium to explain the apparent movement of the sun through the Zodiacal Band. See Figure SP 5.7.5(4).

Light and Seasons
Figure SP 5.7.5(5) provides instruction to make a battery-operated "sun." An electric light bulb can be substituted. In a darkened room the Earth orbital model made from a coat hanger is placed around the bulb sun to demonstrate the lighting of Earth in different seasons.

STUDENT ROLE

Astronomer

MATERIALS

PUSHPIN-AND-PENCIL ORBITAL MODEL
- pieces of corrugated cardboard at least 10 in x 10 in
- pushpins
- small paper clips to tether the Earth model to the sun
- pencils

COAT-HANGER ORBITAL MODEL
AND BATTERY-AND-BULB SUN
- jumbo paper clips for battery wires and axes of Earth models
- modeling clay
- wire coat hangers that are easily bent
- small balls for Earth models (Styrofoam, Ping-Pong, or other)
- large Planetarium from Activity 5.7.2 PLANETARIUM
- electric light bulb, socket, and cord or
  - 1.5-volt D-battery
  - 1.5-volt flashlight bulb (screw-base type)
  - jumbo paper clip
  - rubber bands

string
3 x 5-in index cards
Student Page 5.7.5 WHERE IS EARTH?

PRODUCTS

Where Is Earth? Game
Models of Earth's orbit
Completed Student Pages

PROCEDURES

1. **Introduce the idea that to get a better understanding of our solar system we need to know more about Earth's orbit of the sun at different times of the year. To do this we will make the pushpin-and-pencil model shown in Figures SP 5.7.5(1–3).**

   Help the students
   - Glue the north and south views of the Zodiacal Band together. Place them on a piece of cardboard so that the view from the North Pole is on top. See Figure SP 5.7.5(1). The observer is looking down from above the North Star. The Zodiacal Band can be turned over to get a view looking up from the south. See Figure SP 5.7.5(3).
   - Stick a pushpin representing the sun through a small paper clip. Center the sun on the Zodiacal Band. The paper clip represents the gravitational tie of the sun to Earth. See Figure SP 5.7.5(1).
   - Use a pencil to represent Earth.
   - Attach a piece of paper to the pencil to represent the view plane of an observer living on the side of the pencil. Bend the center tab up to represent an observer. See Figure SP 5.7.5(1).
   - Place the pencil in the loop of the paper clip and draw an orbit of Earth about the sun.

2. **Use the pushpin-and-pencil model and have the students explore to find answers about the movement of the sun and Earth.**

   Ask such questions as these:
   - How can we mark compass points on the view plane? (See Figure SP 5.7.5(3). (Help the students recall the Body Compass mnemonic: Right rising, **EAST**. Left leaving, **WEST**. Nose, **NORTH**. Seat, **SOUTH**.)
   - Where would the observer be on the view plane? (Work to the idea that the observer would be in the center of the view plane.)
   - Does Earth appear to *rotate* (turn on its axis) clockwise or counterclockwise when viewed looking *down* from the north? (Work for agreement that when viewed looking down from the north it appears to rotate counterclockwise. Have the students rotate the pencil so the view plane's eastern edge comes into line with the rising sun. Have them follow the rotation of Earth through the day, placing the sun directly overhead at noon and on the western horizon at sunset.)

- Where is Earth when the sun is "in" Cancer? (Earth will be directly opposite Cancer, so the sun will be in front of Cancer and thus obscure it. Set up the model so that Earth has a position in the direction of Capricornus. This will be opposite Cancer in a direct line with the pushpin sun.)
- What will the midnight sky look like when the sun is in Capricornus? (Get at the observation that Cancer will be directly overhead, Aries will be setting, and Libra will be rising.)
- Does Earth appear to revolve about the sun clockwise or counterclockwise when viewed looking *down* from the north? (Work for agreement that when viewed looking down from the north, it appears to revolve counterclockwise. Have the students advance Earth in its orbit so that the sun is successively in the direction of Aquarius, Pisces, Aries, and so forth.)
- What constellation will be directly overhead at midnight during the winter solstice? (Help the students recall that the sun enters the zodiacal constellations about the middle of the month and that in mid-January the sun is in Capricornus. Using their model, they should find that a month earlier the sun will be in Sagittarius. At midnight the constellation directly overhead will be Gemini, which is 180° from Sagittarius.)

3. **Have the students make game cards and play the Where Is Earth? Game.**

WHERE IS EARTH? GAME

- Have the students work in groups to make three or four game cards using their model to find Earth's position in its orbit on dates they select. Have them write the date on one side of a card. On the other side have them write the zodiacal constellation directly overhead on Earth at midnight on the selected date. For example, from March 12 to April 18 Virgo will be overhead. The sun will appear to be in Pisces.

- Have the students exchange their cards date side up with another group and take turns drawing a card. The drawer of the card uses the model to find the zodiacal constellations overhead on Earth at midnight on the date called for. The player checks the answer by turning over the card. The player with the most correct answers wins.

4. **Have the students make a second model to show Earth's orientation in relation to the ecliptic at various points as it moves in its orbit about the sun.**

   Such a model can be made in the following way:
   - Bend a coat hanger as shown in Figure SP 5.7.5(4) to represent the orbit. Make its diameter small enough to fit in the large Planetarium with 1–2 inches of clearance.
   - Bend in four notches 90° apart to hold models of Earth.
   - To make a model of Earth straighten a paper clip (and make a hook in its middle) to act as the axis of the model Earth (a small ball). See Figure SP 5.7.5(4).
   - Run the axis through the model Earth and press a piece of clay on the opposite end to act as a counterbalance.

5. **Have the students explore with the model to answer questions about Earth's orbit. Use a single model Earth.**

   Ask such questions as the following:
   - Where is the North Pole? (Establish that the upper part of the axis is the North Pole. Have the students mark this.)
   - Have the students turn the orbital ring with a model Earth on it through 360°. Where does the pole point? (Work for agreement that it always points in the same direction. Have the students help each other correct mechanical problems with the model such as restricted movement of the Earth model because the bend in a notch is too tight.)
   - Have the students tilt the orbital ring about 23° (parallel with the ecliptic) and again turn it through a 360° circle. Where does the North Pole point? (Work for agreement that it still always points in the same direction—north. Have the students continue to help each other correct mechanical problems.)
   - Suspend a ball or wad of paper in the middle of the orbital ring to represent the sun.
   - Put the model orbital ring in the large Planetarium and view the system from below. Where would Earth be in relation to the sun at the winter solstice on December 22? (Work for agreement that Earth would be in the direction of Gemini and the sun would appear to be in the direction of Sagittarius.)
   - How is the orbital ring oriented in the Planetarium? (Work for agreement that it is oriented so that it tilts about 23° and that Earth is at its most northern point in its orbit through the heavens on December 22.)

- Where does the North Pole point? (It will continue to point in the same direction in the sky. Because of the small size of our Planetarium, Earth's pole cannot point directly to the North Star. However, in the great distances of the real universe it points toward the North Star at all times.)
- Where would Earth be at the summer solstice on June 22? (Help the students see that Earth is now at the most southern point in its orbit through the heavens.)

6. **If electric light bulbs, sockets, and cords are not available, have the students make a battery-bulb sun using a setup similar to the one shown in Figure SP 5.7.5(5). If an electric system is available, go on to Procedure 7.**

Have the students
- Bend a large paper clip around the screw-end of the bulb.
- Bend the other end of the wire so that it comes in contact with the base of the battery.
- Attach the bulb to the battery as shown in the diagram. At this point the bulb should light.
- Secure the system with a rubber band.
- Remove the ball from the center of the orbital ring.

7. **Have the students place their bulb sun in the center of the orbital ring and darken the room. Have them tilt the ring so that the poles of Earth cut across it at about 23°. Use four models of Earth in the notches so the lighting at the equinoxes and solstices can be compared. Have the students explore with the model.**

Ask such questions as these:
- What represents the plane of the ecliptic? (Work for agreement that it is represented by the orbital ring of the model.)
- What part of our model Earth is lighted during daylight hours on December 22, the winter solstice? (Have the students demonstrate. Work for agreement that more of the Southern Hemisphere is lighted than the Northern Hemisphere.)
- What part of our model Earth is lighted during daylight hours on June 22, the summer solstice? (Have them demonstrate and work for agreement that more of the Northern Hemisphere is lighted than the Southern Hemisphere.)

- What part of our model Earth is lighted during daylight hours at the equinoxes? (Have them demonstrate. Work for agreement that Earth is equally lighted from pole to pole.)
- How does this model help explain the seasons? (Have the students demonstrate how the model explains why there is more light in each hemisphere in its summer and less in its winter.)
- How does this model explain the six months of light and six months of darkness at the poles? (Have the students demonstrate on the model how the light shifting north or south at the time of the equinoxes completely bathes either the North or South Pole or both on the days of the equinox.)
- What else does this set of models tell us about Earth's movement in relation to the sun? (Have the students list their findings and report and demonstrate them.)

EXTENSIONS

Have the students

- Research Johannes Kepler's work with elliptical orbits.
- Research the reason we are closer to the sun on January 1 and farthest away on July 1.

DASH

Name ____________________

Date ____________________

STUDENT PAGE 5.7.5 WHERE IS EARTH?

1. Construct a pushpin-and-pencil model of the sun, Earth, and Zodiacal Band. Use Figures SP 5.7.5(1–3).

2. As an observer looking down from above the North Star, describe how Earth rotates on its axis.

3. As an observer looking down from above the North Star, describe Earth's revolution about the sun.

4. Assemble Earth's orbital ring and four Earth models. See Figure SP 5.7.5(4).

5. Explain how the sun appears to travel in the path of the ecliptic through the Zodiacal Band.

Name ______________________

6. Assemble a model to show Earth's seasonal lighting by the sun. See Figure SP 5.7.5(5). Explain how Earth's path along the ecliptic produces seasons.

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ILLUSTRATIONS

Name ______________________________

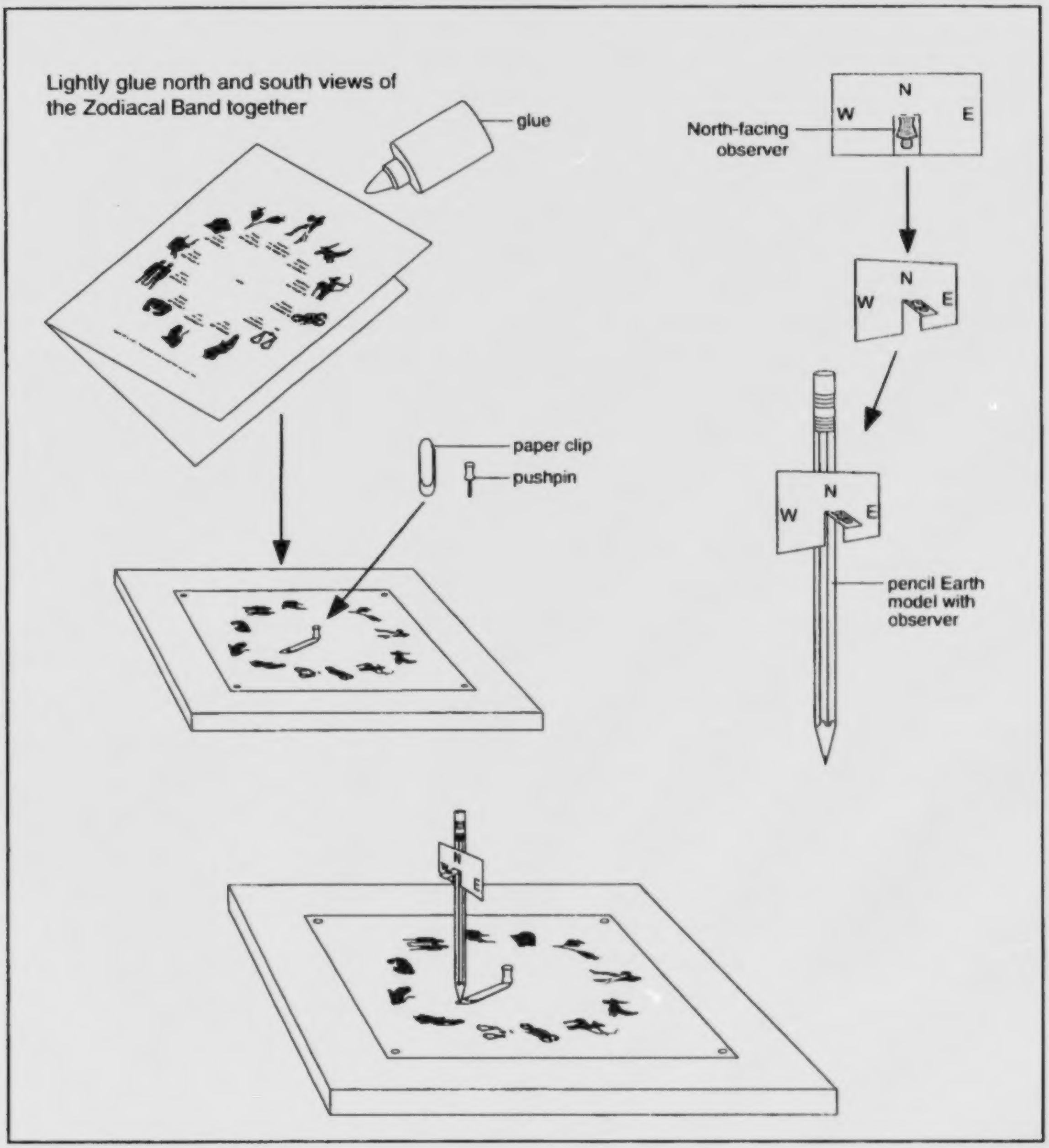

Lightly glue north and south views of the Zodiacal Band together
glue
N
W
E
North-facing observer
N
W
E
paper clip
pushpin
N
W
E
pencil Earth model with observer
N
E

Figure SP 5.7.5(1) Construction of a push-pin-and-pencil model of the sun, Earth, and Zodiacal Band

Name ______________________________

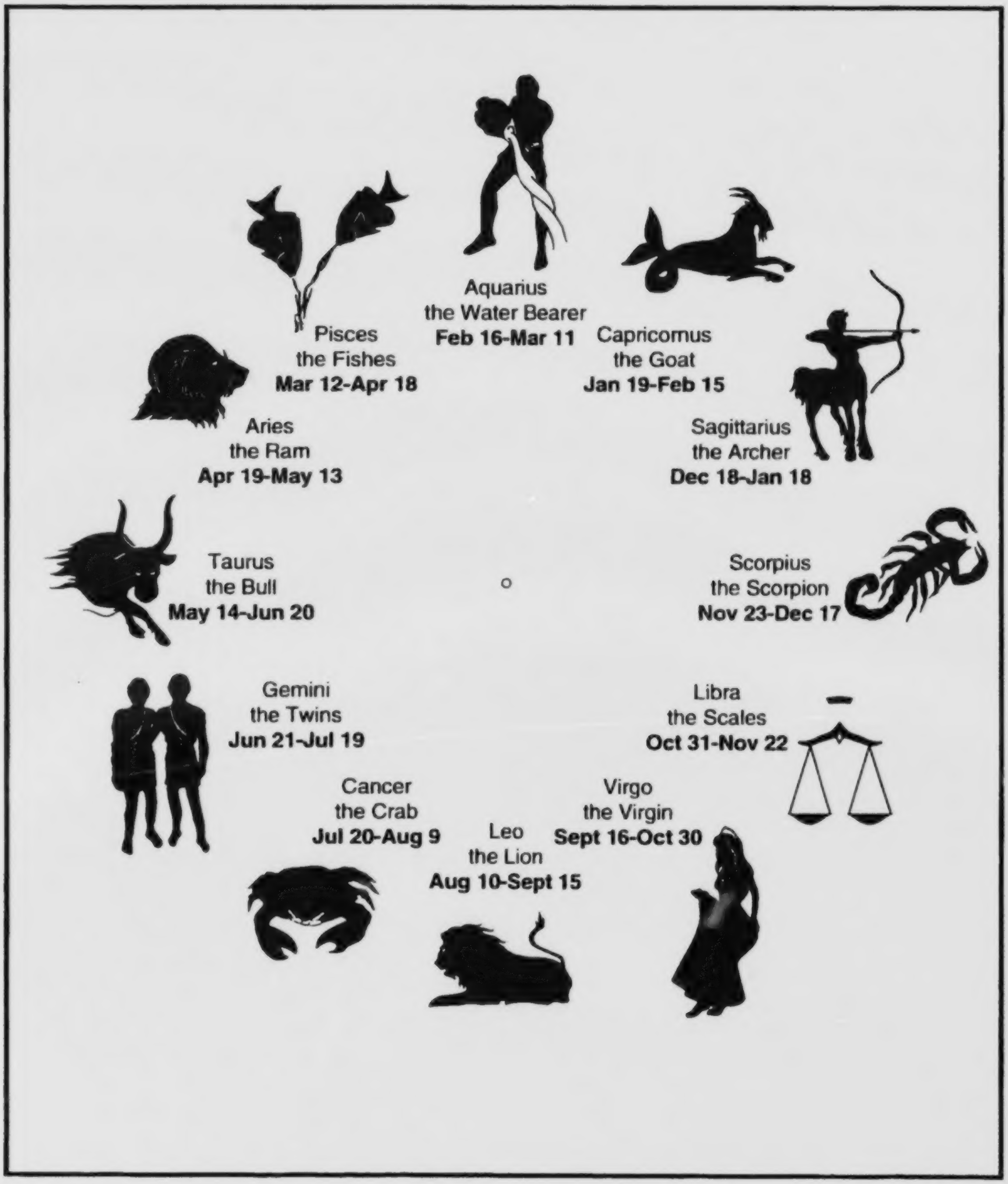

Aquarius
the Water Bearer
Feb 16-Mar 11
Capricornus
the Goat
Jan 19-Feb 15
Sagittarius
the Archer
Dec 18-Jan 18
Scorpius
the Scorpion
Nov 23-Dec 17
Libra
the Scales
Oct 31-Nov 22
Virgo
the Virgin
Sept 16-Oct 30
Leo
the Lion
Aug 10-Sept 15
Cancer
the Crab
Jul 20-Aug 9
Gemini
the Twins
Jun 21-Jul 19
Taurus
the Bull
May 14-Jun 20
Aries
the Ram
Apr 19-May 13
Pisces
the Fishes
Mar 12-Apr 18

Figure SP 5.7.5(2) The Zodiacal Band viewed looking down from the North Star

Name ______________________________

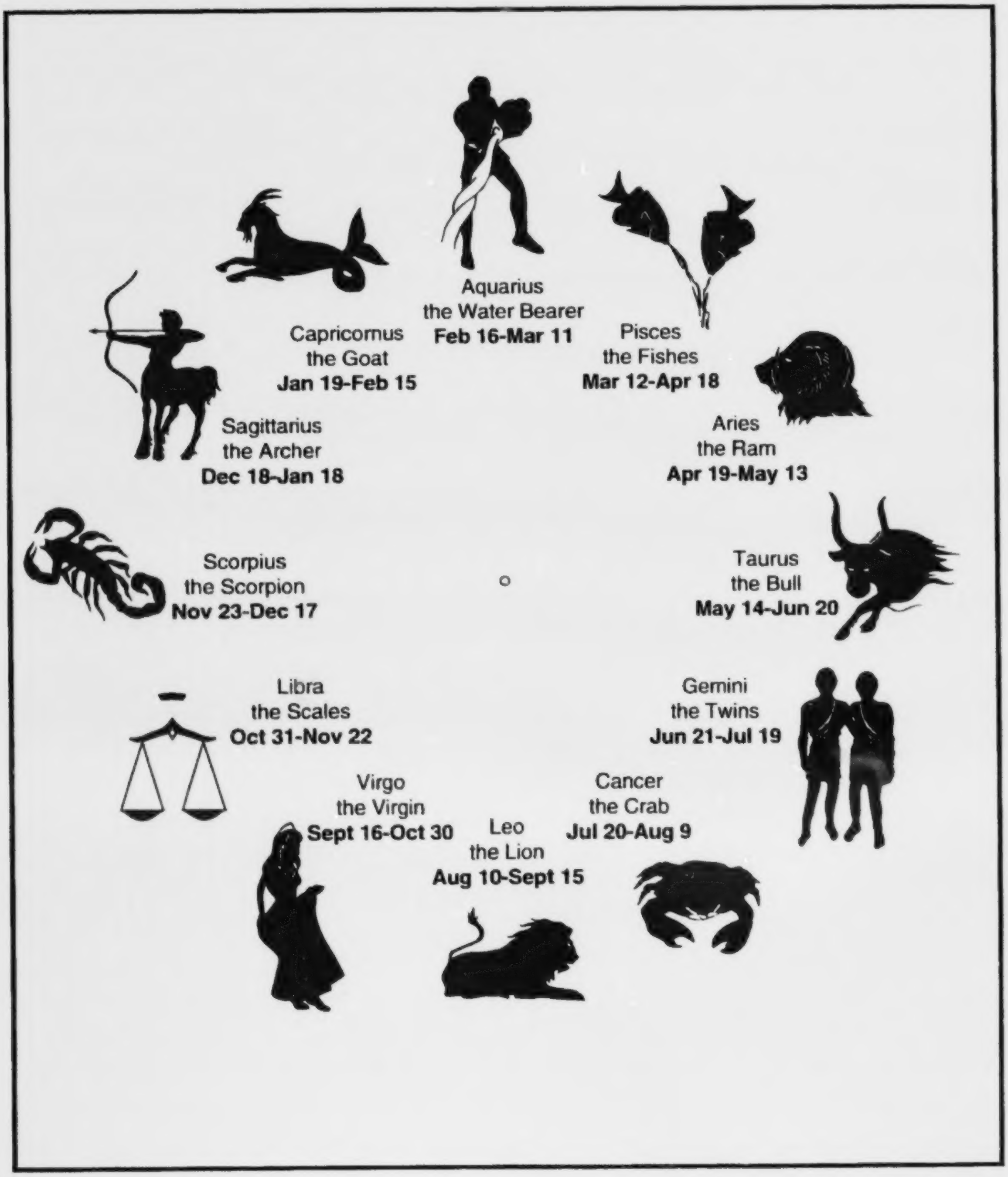

Aquarius
the Water Bearer
Feb 16-Mar 11
Pisces
the Fishes
Mar 12-Apr 18
Capricornus
the Goat
Jan 19-Feb 15
Aries
the Ram
Apr 19-May 13
Sagittarius
the Archer
Dec 18-Jan 18
Taurus
the Bull
May 14-Jun 20
Scorpius
the Scorpion
Nov 23-Dec 17
Libra
the Scales
Oct 31-Nov 22
Gemini
the Twins
Jun 21-Jul 19
Virgo
the Virgin
Sept 16-Oct 30
Cancer
the Crab
Jul 20-Aug 9
Leo
the Lion
Aug 10-Sept 15

Figure SP 5.7.5(3) The Zodiacal Band viewed looking up from the south

Name ______________________________

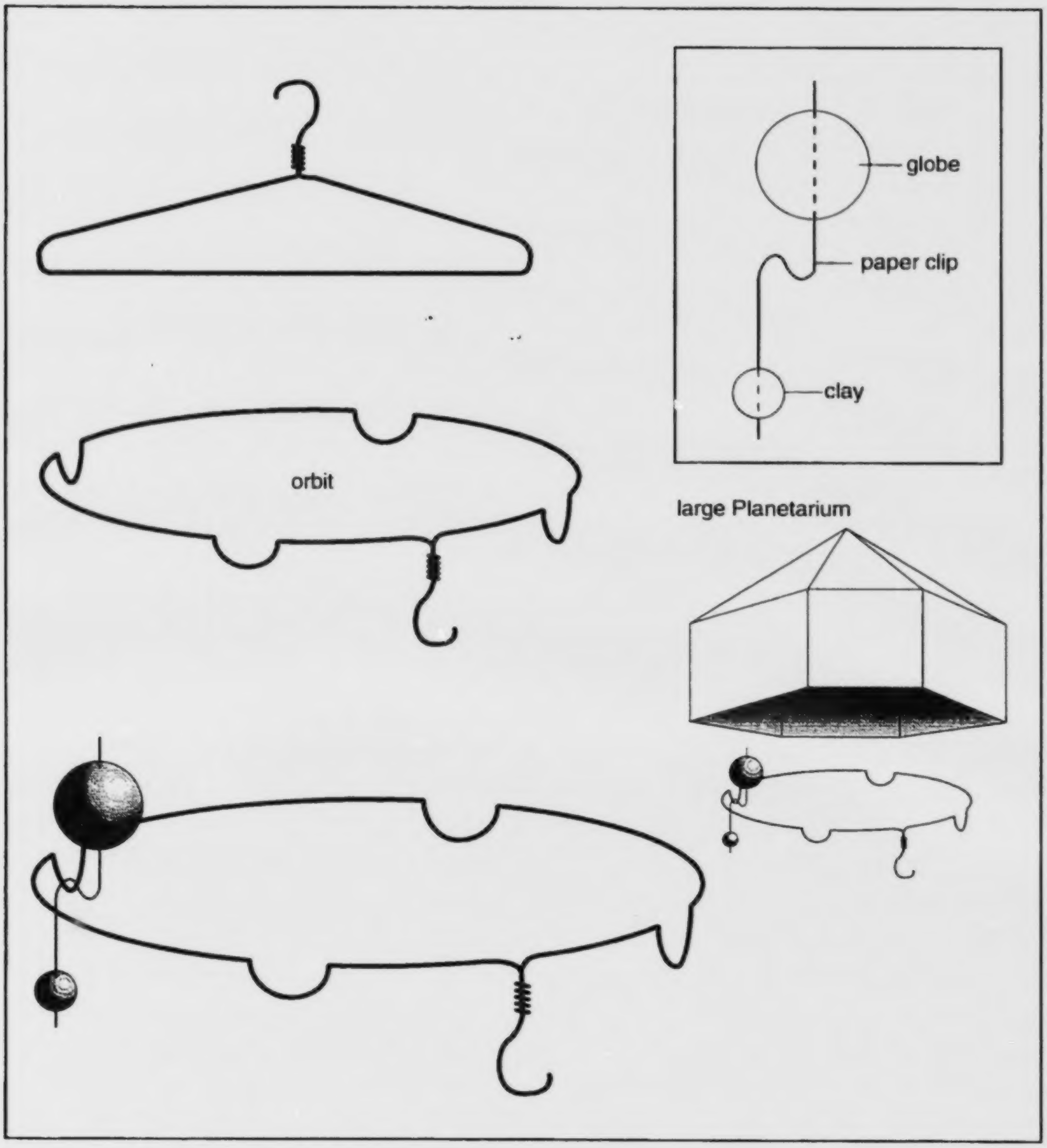

globe
paper clip
clay
orbit
large Planetarium

Figure SP 5.7.5(4) Construction of a coat-hanger orbital model to fit in large Planetarium

Name ______________________________

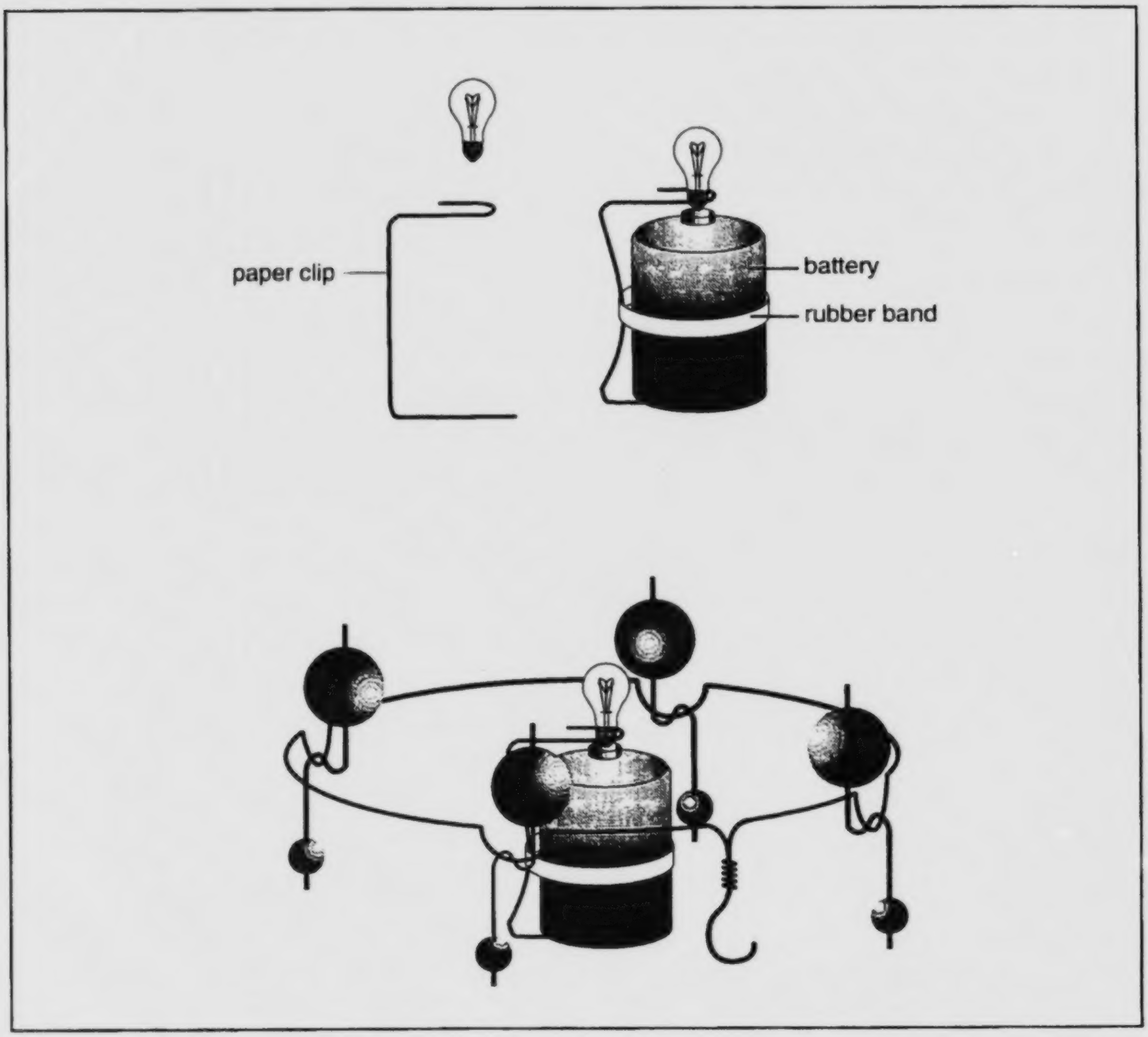

paper clip
battery
rubber band

Figure SP 5.7.5(5) Construction of a battery-and-bulb sun to fit on orbital model to show Earth's seasonal lighting

Name________________________

Date________________________

DASH

STUDENT PAGE 5.7.1 WHERE IN THE WORLD ARE WE?

1. Give directions to find your home or the home of a friend.

2. Give directions for finding your home on a globe.

Name ____________________

3. Record your working definitions for the following terms:

a) latitude

____

____

b) longitude

____

____

c) coordinates

____

____

d) prime meridian

____

____

e) international date line

____

____

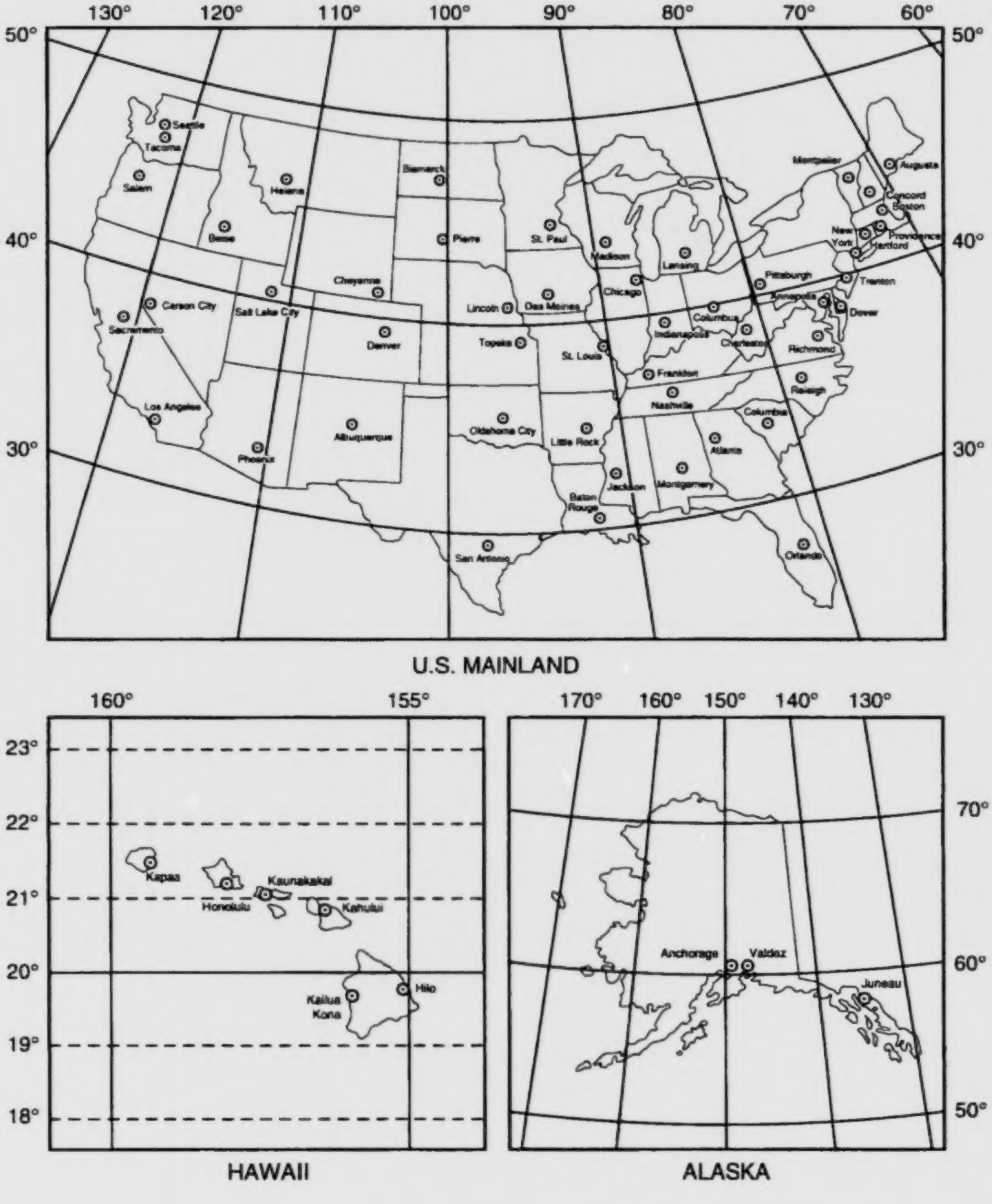
f) meridian

____

____

ILLUSTRATIONS

Name ______________________________


130°
120°
110°
100°
90°
80°
70°
60°
50°
40°
30°
Seattle
Tacoma
Salem
Helena
Boise
Carson City
Sacramento
Salt Lake City
Cheyenne
Denver
Los Angeles
Phoenix
Albuquerque
Bismarck
Pierre
Lincoln
Topeka
Oklahoma City
San Antonio
St. Paul
Des Moines
St. Louis
Little Rock
Baton Rouge
Jackson
Madison
Chicago
Lansing
Indianapolis
Columbus
Frankfort
Nashville
Montgomery
Atlanta
Charleston
Columbia
Orlando
Raleigh
Richmond
Pittsburgh
Annapolis
Dover
Trenton
New York
Hartford
Providence
Boston
Concord
Montpelier
Augusta
160°
155°
23°
22°
21°
20°
19°
18°
Kapaa
Honolulu
Kaunakakai
Kahului
Kailua Kona
Hilo
170°
160°
150°
140°
130°
70°
60°
50°
Anchorage
Valdez
Juneau

U.S. MAINLAND

HAWAII

ALASKA

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Figure SP 5.7.1(1) Map of the United States

Name ________________________________

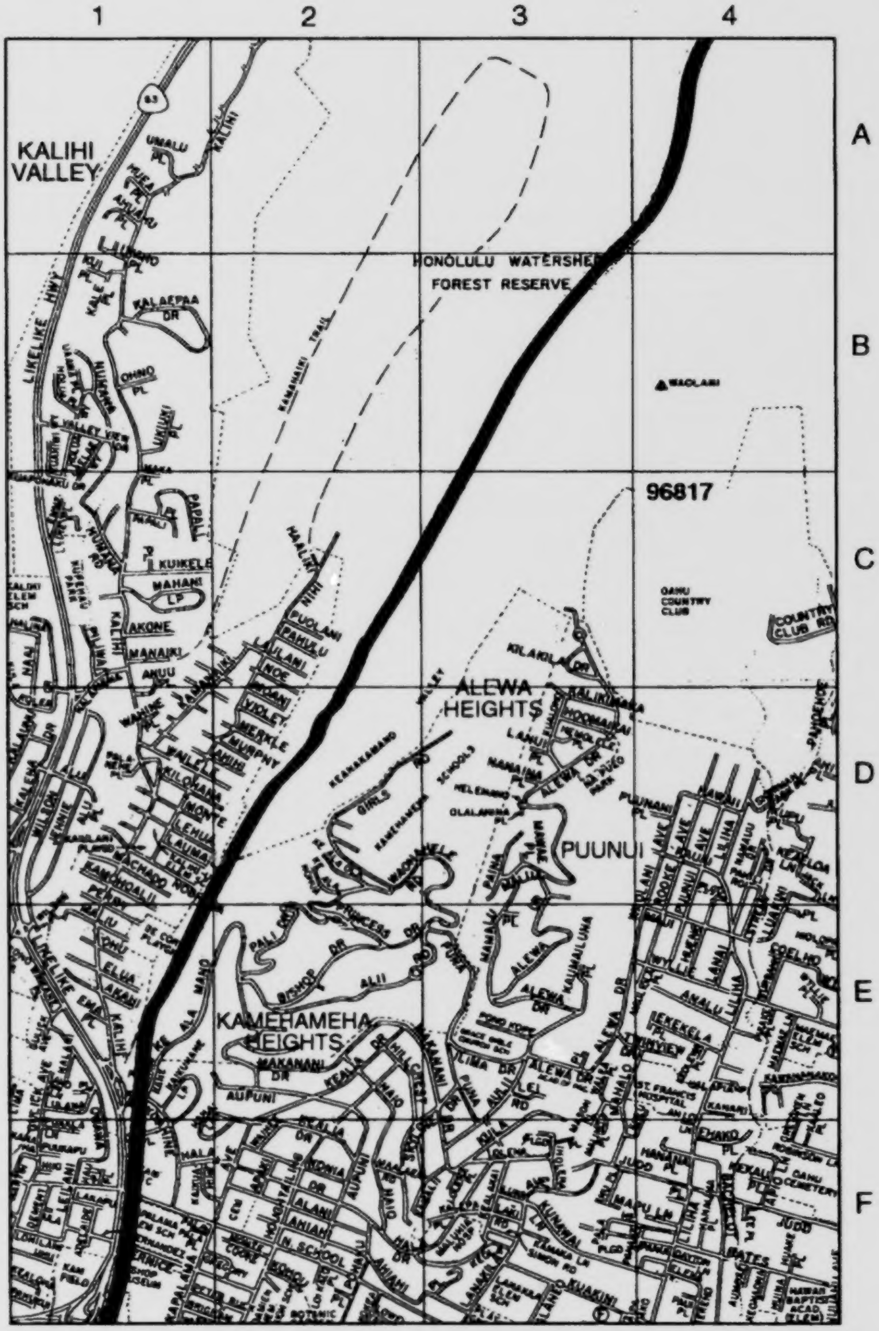
1
2
3
4
A
B
C
D
E
F
KALIHI VALLEY
HONOLULU WATERSHED FOREST RESERVE
LIKELIKE HWY
KALIHI
96817
OAHU COUNTRY CLUB
COUNTRY CLUB RD
ALEWA HEIGHTS
PUUNUI
KAMEHAMEHA HEIGHTS
NAOLANI

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Figure SP 5.7.1(2) Honolulu street map

DASH

Name________________________

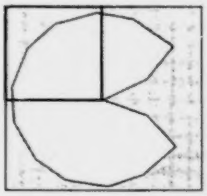
Date________________________

STUDENT PAGE 5.7.2A PERSONAL PLANETARIUM

Make a small model Planetarium by assembling the 4 IN and the 4 OUT sheets. The following instructions give one way to assemble the model:

- Glue together the 4 IN sheets, overlapping them to cover the "glue edge" markings.
- Cut out the glued-together pieces along the dark lines.
- Fold the IN cutout into a six-sided tent using the dashed lines radiating from Polaris as a guide. At the large opening, glue Cepheus and Lacerta so they overlap the tab opposite them.
- Close the sides of the tent by gluing the long straight edges of the V-cuts onto the tabs next to them.
- Assemble the 4 OUT sheets in the same way to make the outside view of the Planetarium.
- Slide the outside over the inside. Be sure the same constellations are together (one over the other) on the inside and outside of the Planetarium.

DASH—IN



North Celestial Pole
Zodiac, R.A., Dec.

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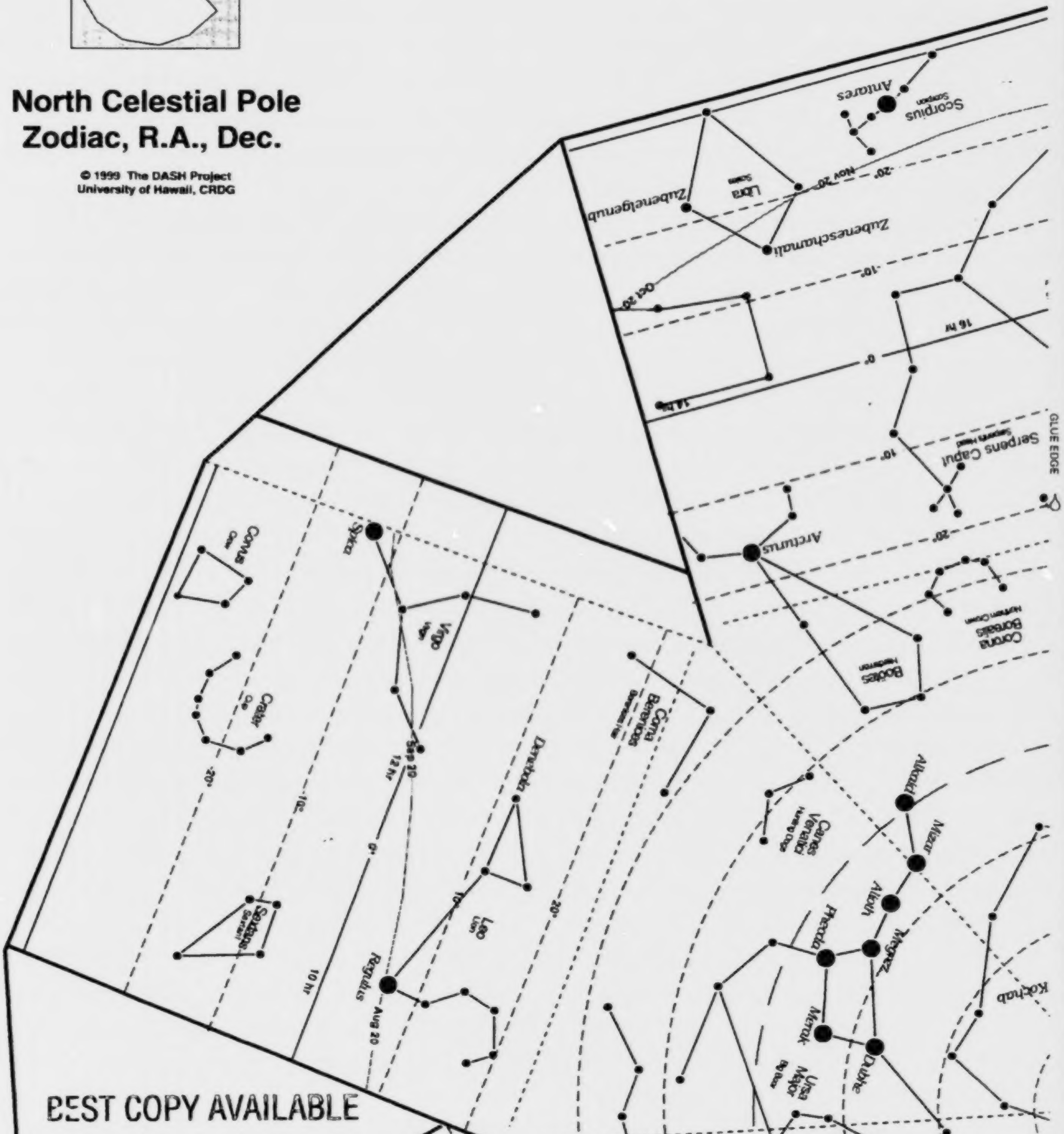
CUT ALONG INSIDE OF DOTTED LINE


Antares
Scorpius
Scorpion
Libra
Scales
Zubenelgenubi
Zubeneschamali
Nov 20
-20°
-10°
Oct 20
16 hr
0°
14 hr
Serpens Caput
Serpent's Head
10°
GLUE EDGE
Arcturus
20°
Corona Borealis
Northern Crown
Bootes
Herdsman
Corvus
Crow
Crater
Cup
Spica
Virgo
Virgin
Coma Berenices
Bernice's Hair
Denebola
Sep 20
12 hr
-20°
-10°
0°
10°
20°
Leo
Lion
Sextans
Sextant
10 hr
Regulus
Aug 20
Alkaid
Mizar
Canes Venatici
Hunting Dogs
Alioth
Phecda
Megrez
Kochab
Merak
Dubhe
Ursa Major
Big Bear

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GLUE EDGE

DASH—IN

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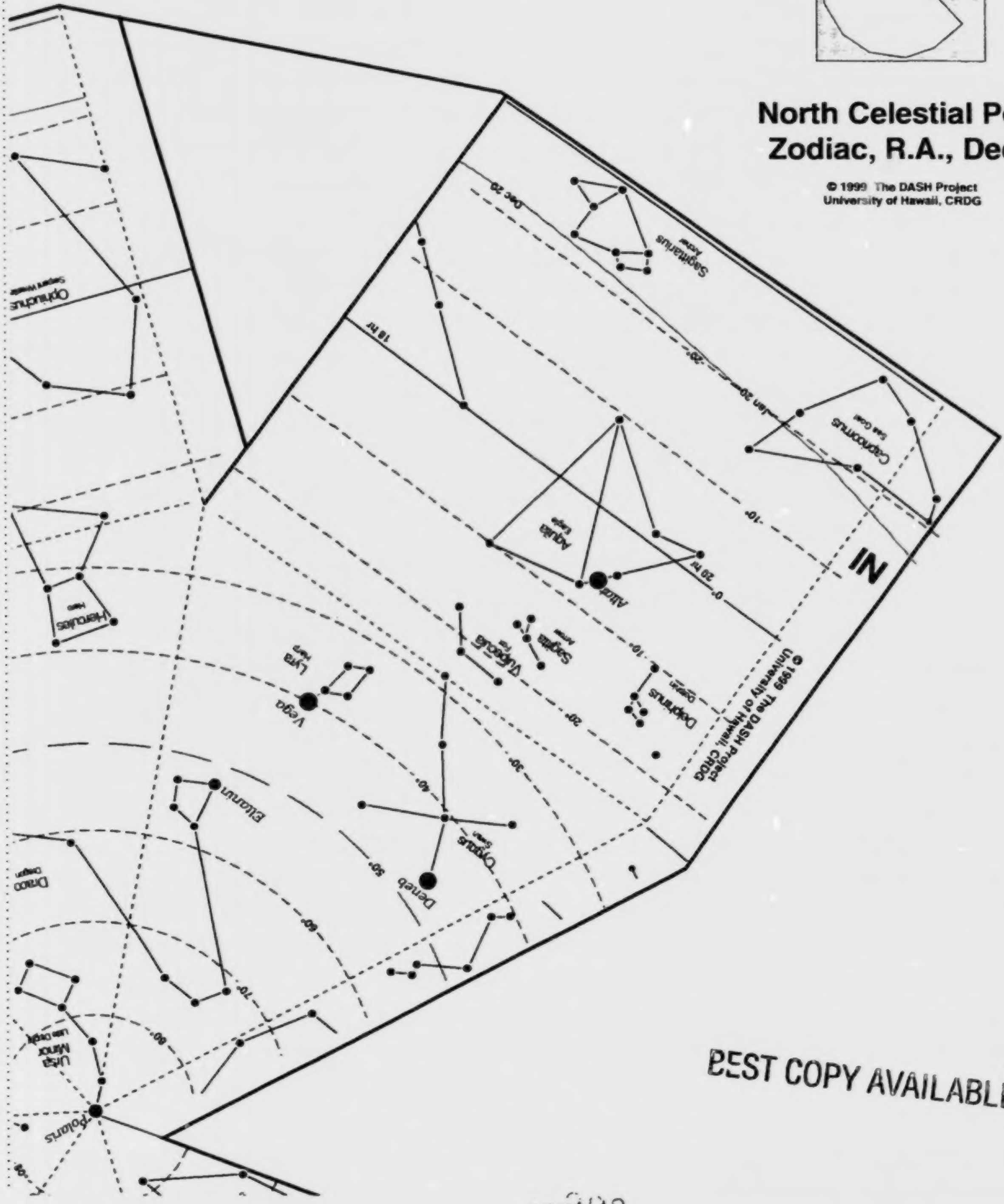
CUT ALONG INSIDE OF DOTTED LINE


Sagittarius
Archer
Dec 20
Capricornus
Sea Goat
18 hr
Jan 20
-20°
-10°
0°
10°
20°
30°
40°
50°
60°
70°
80°
20 hr
Aquila
Eagle
Altair
IN
Sagitta
Arrow
Vulpecula
Fox
Delphinus
Dolphin
© 1999 The DASH Project
University of Hawaii, CRDG
Lyra
Harp
Vega
Hercules
Hero
Ophiuchus
Serpent Wrestler
Eltanin
Cygnus
Swan
Deneb
Draco
Dragon
Ursa Minor
Little Dipper
Polaris

GLUE EDGE

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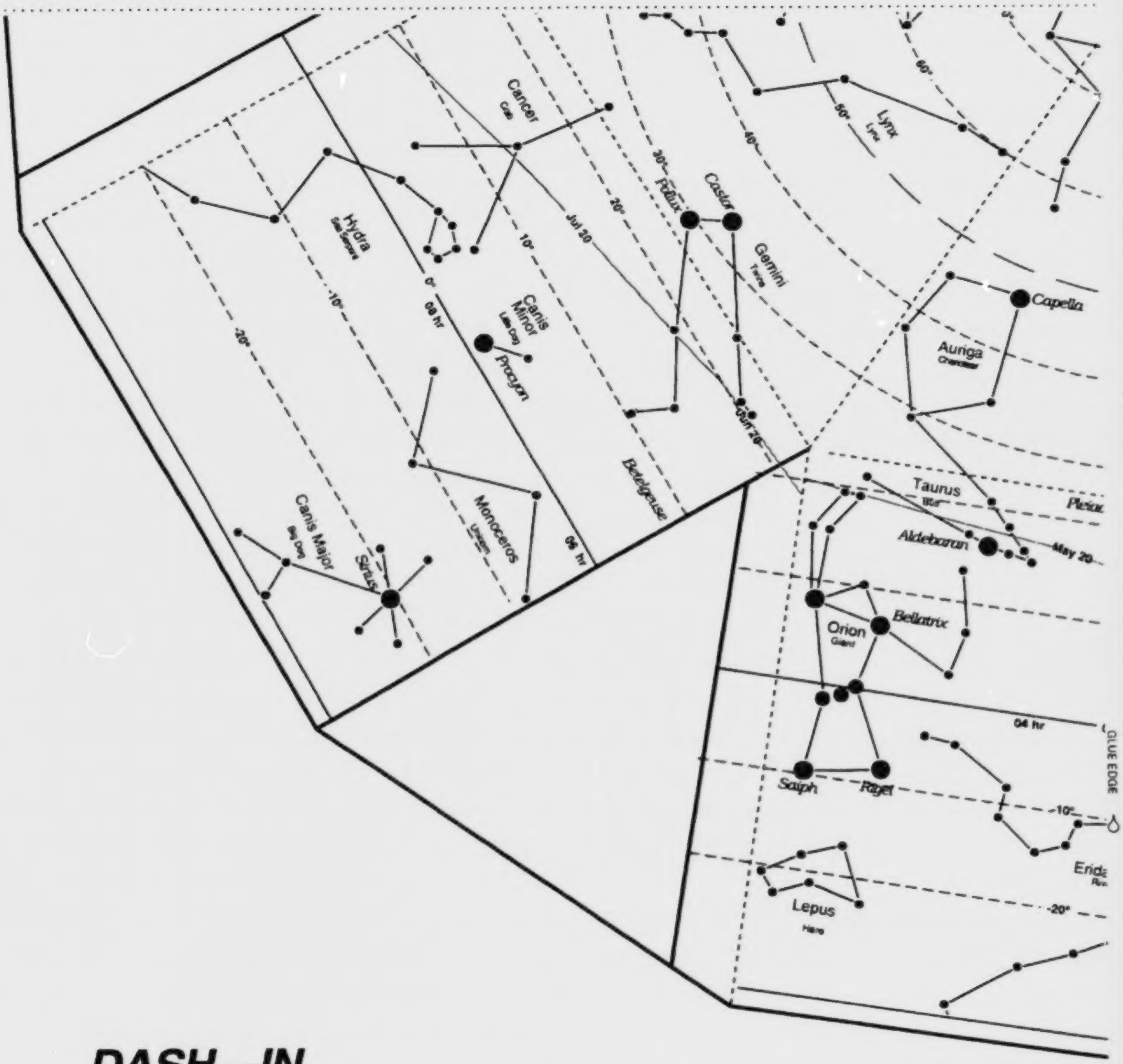
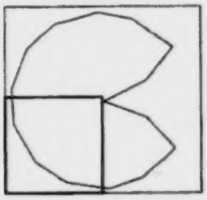
GLUE EDGE

CUT ALONG INSIDE OF DOTTED LINE


Cancer
Crab
Lynx
Lynx
60°
50°
40°
30°
20°
10°
0°
-10°
-20°
Pollux
Castor
Gemini
Twins
Jul 20
Hydra
Sea Serpent
Canis Minor
Little Dog
Procyon
08 hr
Capella
Auriga
Charioteer
Jun 20
Betelgeuse
Monoceros
Unicorn
06 hr
Canis Major
Big Dog
Sirius
Taurus
Bull
Pleiac
Aldebaran
May 20
Bellatrix
Orion
Giant
04 hr
Saiph
Rigel
-10°
Erida
Lepus
Hare
-20°

GLUE EDGE

DASH—IN



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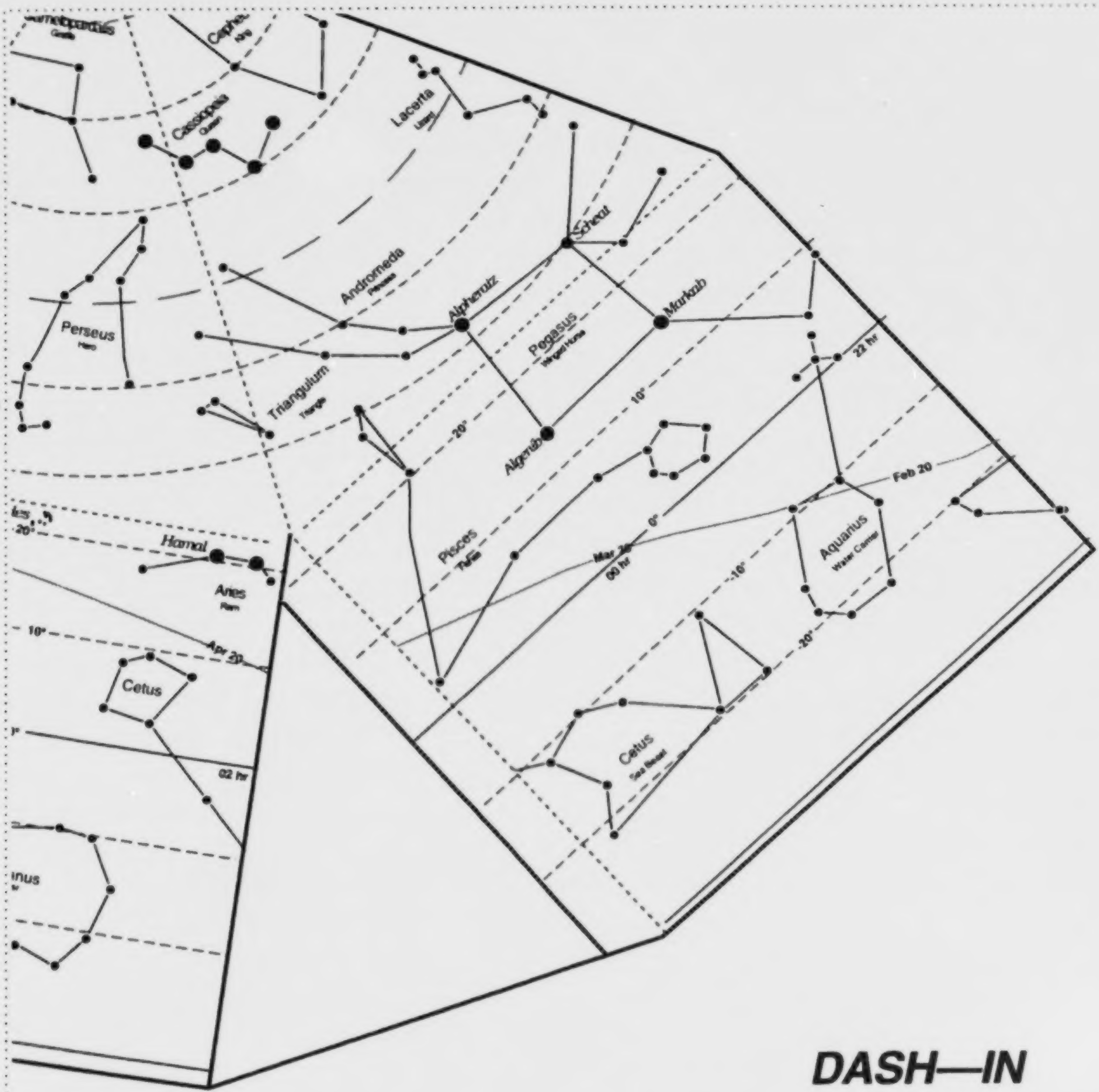
GLUE EDGE

CUT ALONG INSIDE OF DOTTED LINE


Camelopardalis
Giraffe
Cepheus
King
Cassiopeia
Queen
Lacerta
Lizard
Perseus
Hero
Andromeda
Princess
Scheat
Alpheratz
Markab
Pegasus
Winged Horse
Triangulum
Triangle
20°
10°
22 hr
Algenib
Pisces
Fishes
0°
Feb 20
Mar 20
00 hr
Aquarius
Water Carrier
-10°
-20°
Hamal
Aries
Ram
20°
10°
Apr 20
Cetus
02 hr
Cetus
Sea Beast
inus

GLUE EDGE

DASH—IN

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Zodiac, R.A., Dec.

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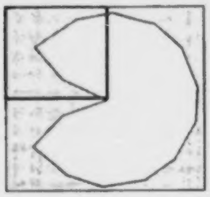
GLUE EDGE

CUT ALONG INSIDE OF DOTTED LINE

DASH—OUT



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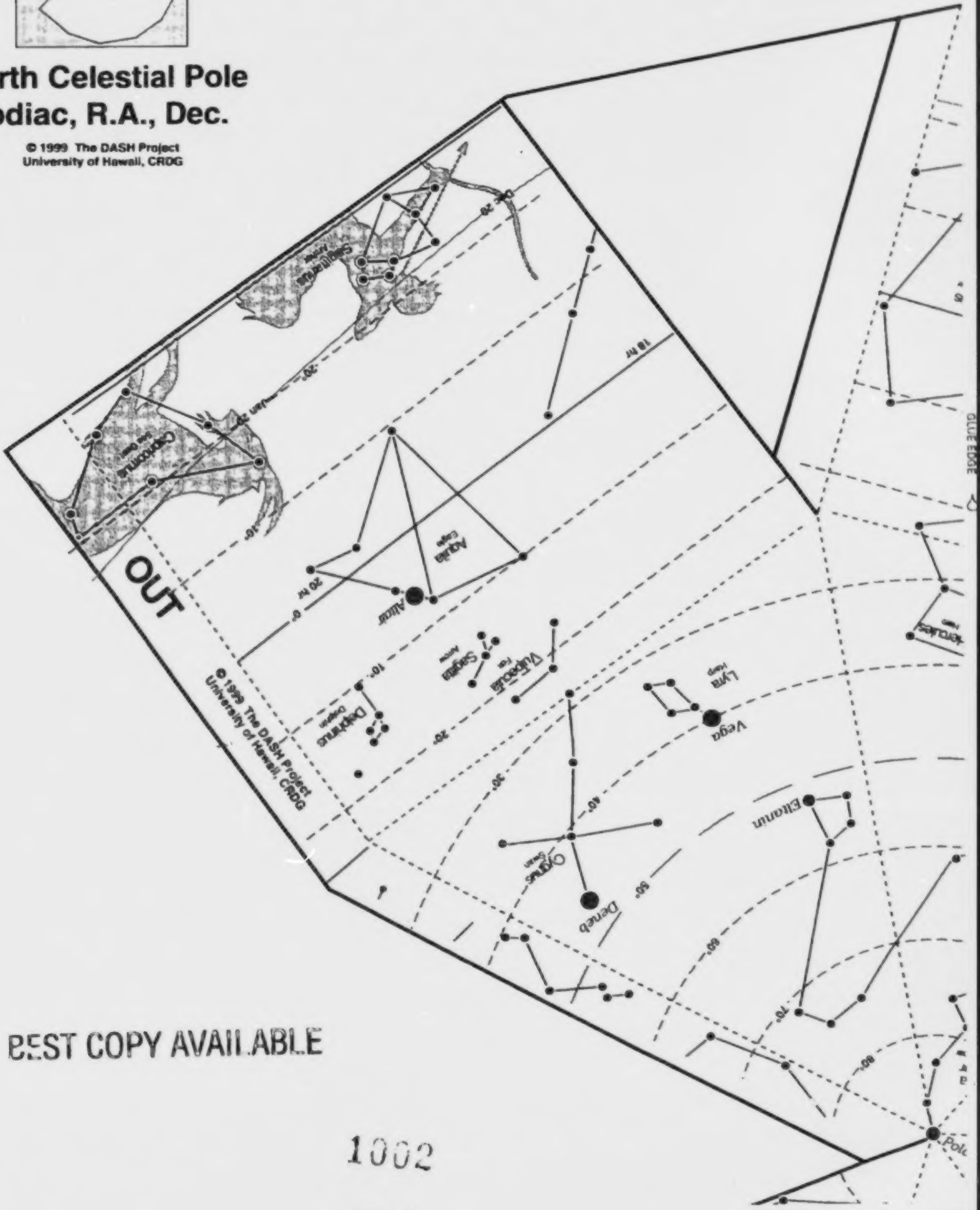
Sagittarius
Archer
Capricornus
Sea Goat
Dec. 20
-20°
-10°
18 hr
20 hr
0°
10°
20°
30°
40°
50°
60°
70°
80°
Aquila
Eagle
Altair
Sagitta
Arrow
Vulpecula
Fox
Delphinus
Dolphin
Lyra
Harp
Vega
Cygnus
Swan
Deneb
Eltanin
Hercules
Pole
OUT
© 1999 The DASH Project
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GLUE EDGE

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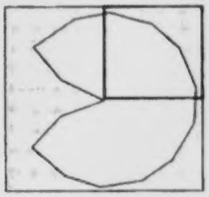
1002

GLUE EDGE

DASH—OUT



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Zodiac, R.A., Dec.

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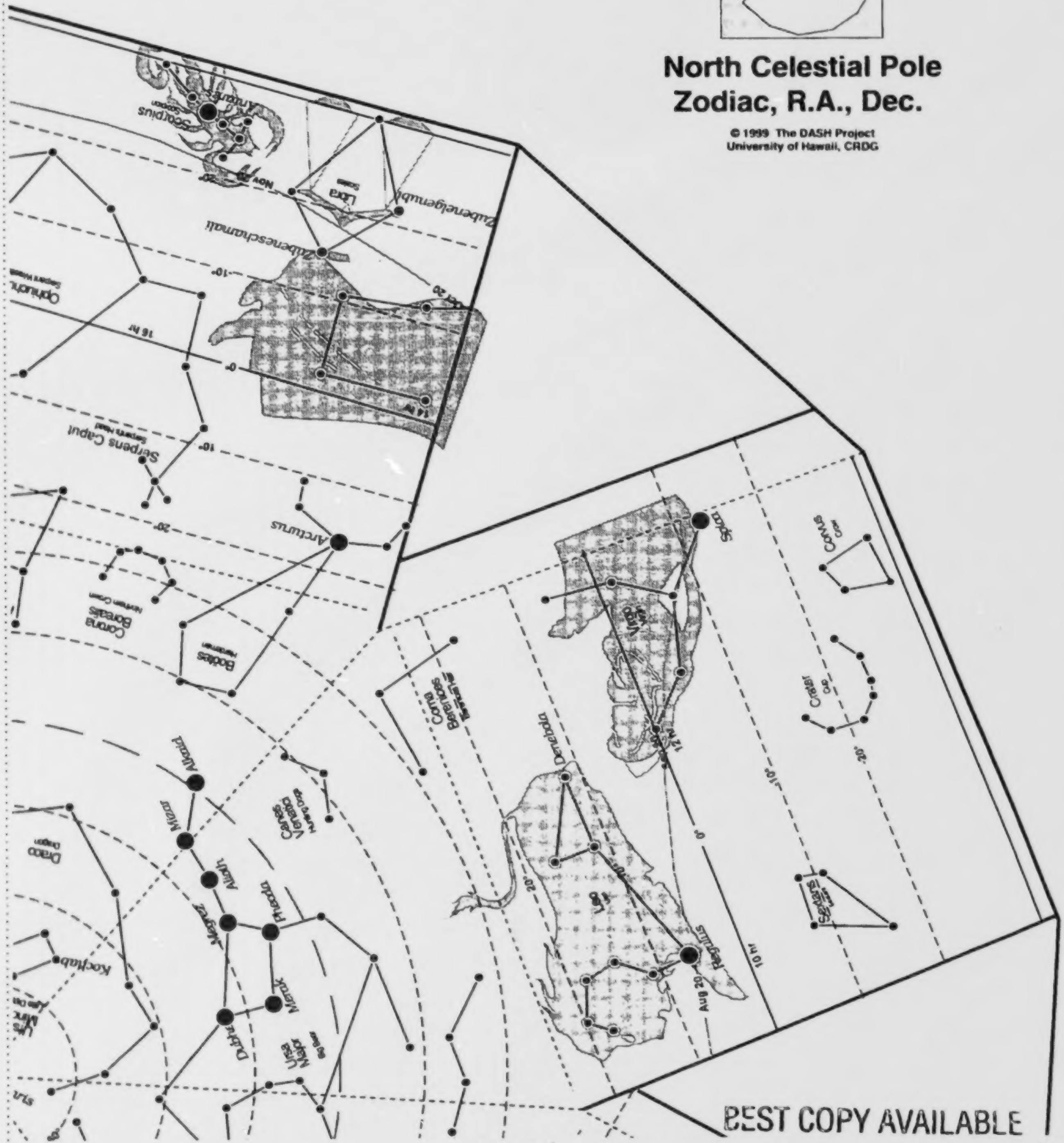
CUT ALONG INSIDE OF DOTTED LINE


Scorpius
Scorpion
Antares
Nov 20
Libra
Scales
Zubenelgenubi
Zubeneschamali
Ophiuchus
Serpent Holder
16 hr
14 hr
Oct 20
-10°
0°
10°
20°
Serpens Caput
Serpent's Head
Arcturus
Corona Borealis
Northern Crown
Bootes
Herdsman
Coma Berenices
Berenice's Hair
Canes Venatici
Hunting Dogs
Alkaid
Mizar
Alioth
Megrez
Phecda
Merak
Dubhe
Ursa Major
Big Bear
Ursa Minor
Little Dipper
Kochab
Draco
Dragon
Spica
Virgo
Virgin
12 hr
Corvus
Crow
Crater
Cup
Sextans
Sextant
Denebola
Leo
Lion
Regulus
Aug 20
10 hr
-20°
-10°

GLUE EDGE

GLUE EDGE

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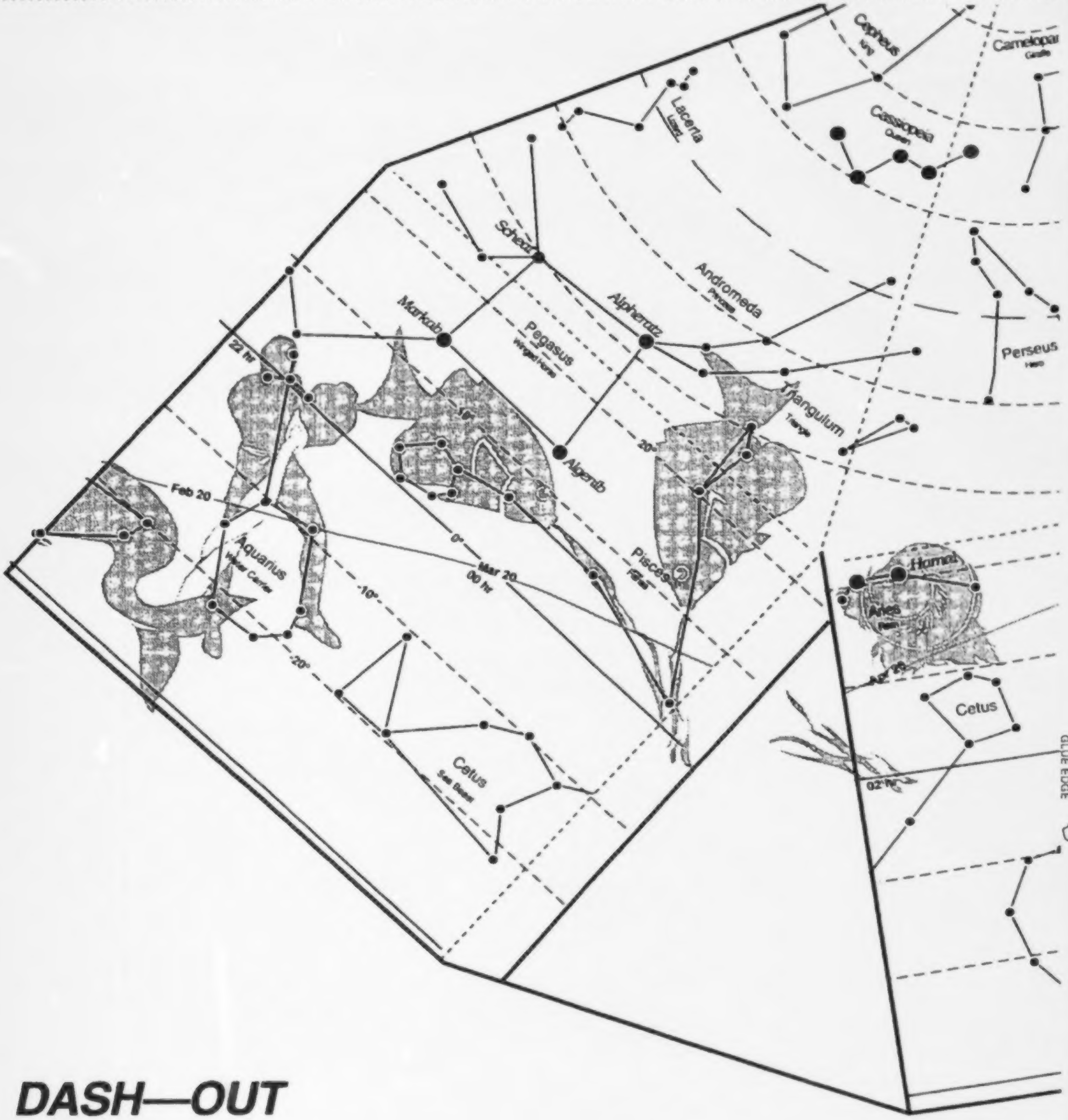
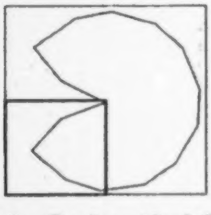
CUT ALONG INSIDE OF DOTTED LINE


Cepheus
King
Camelopar
Giraffe
Lacerta
Lizard
Cassiopeia
Queen
Scheat
Markab
Pegasus
Winged Horse
Alpheratz
Andromeda
Princess
Perseus
Hero
Triangulum
Triangle
Algenib
Pisces
Fish
Aquarius
Water Carrier
22 hr
Feb 20
Mar 20
00 hr
0°
20°
-10°
-20°
Cetus
Sea Beast
Hamal
Aries
Ram
Cetus
02 hr

GLUE EDGE

DASH—OUT



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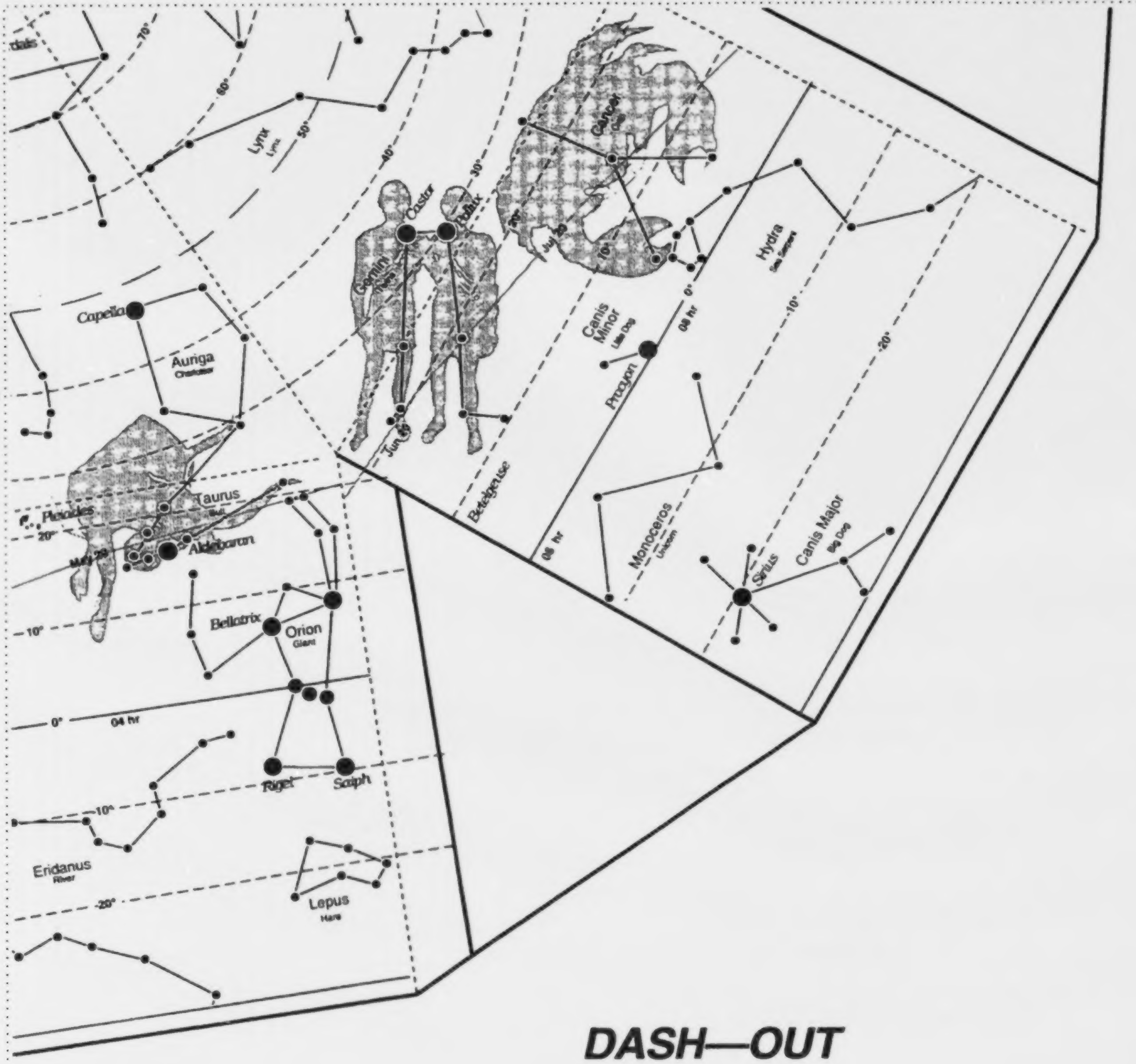
GLUE EDGE

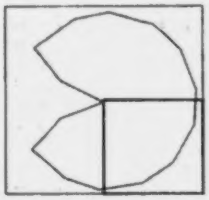
CUT ALONG INSIDE OF DOTTED LINE



Lynx
Lynx
70°
60°
50°
40°
30°
20°
10°
0°
-10°
-20°
Castor
Pollux
Gemini
Twins
Cancer
Crab
Jul 29
Jun 29
May 29
Capella
Auriga
Charioteer
Canis Minor
Little Dog
Procyon
08 hr
06 hr
04 hr
Hydra
Sea Serpent
Betelgeuse
Monoceros
Unicorn
Canis Major
Big Dog
Sirius
Taurus
Bull
Pleiades
Aldebaran
Bellatrix
Orion
Giant
Rigel
Saiph
Eridanus
River
Lepus
Hare

GLUE EDGE

DASH—OUT



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GLUE EDGE

DASH

Name__________________________

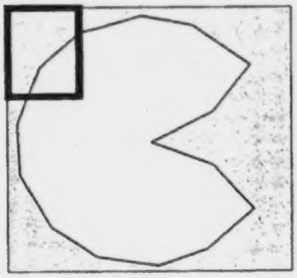
Date__________________________

STUDENT PAGE 5.7.2B LARGE PLANETARIUM

Make a large model Planetarium by assembling the 12 IN and 12 OUT sheets. Use the small Planetarium as a guide. The following is one way to assemble the model:

- Glue together the 12 IN sheets, overlapping them to cover the "glue edge" markings.
- Cut out the glued-together pieces along the dark lines.
- Fold the cutout into a six-sided tent using the dashed lines radiating from Polaris as a guide. At the large open cut, glue Cepheus and Lacerta so they overlap the tab opposite them.
- Close the bottom of the tent by gluing the deep-cut straight edges of the V-cuts onto the tabs next to them.
- Assemble the 12 OUT sheets of the Planetarium the same way.
- Slide the outside over the inside. Be sure the same constellations are together (one over the other) on the inside and outside of the Planetarium.

DASH—IN



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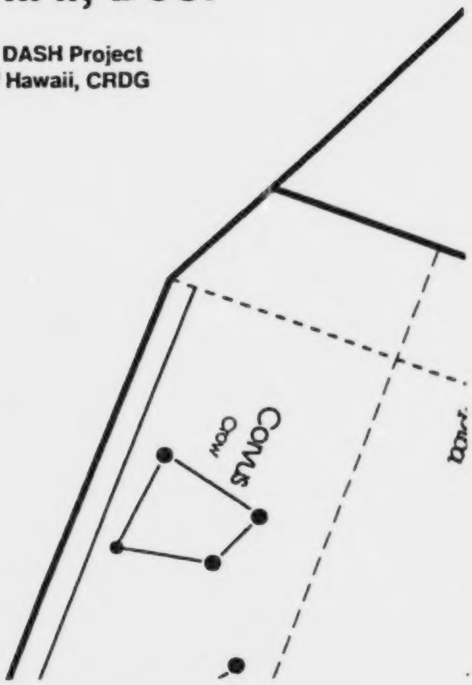
GLUE EDGE



GLUE EDGE

CUT ALONG INSIDE OF DOTTED LINE

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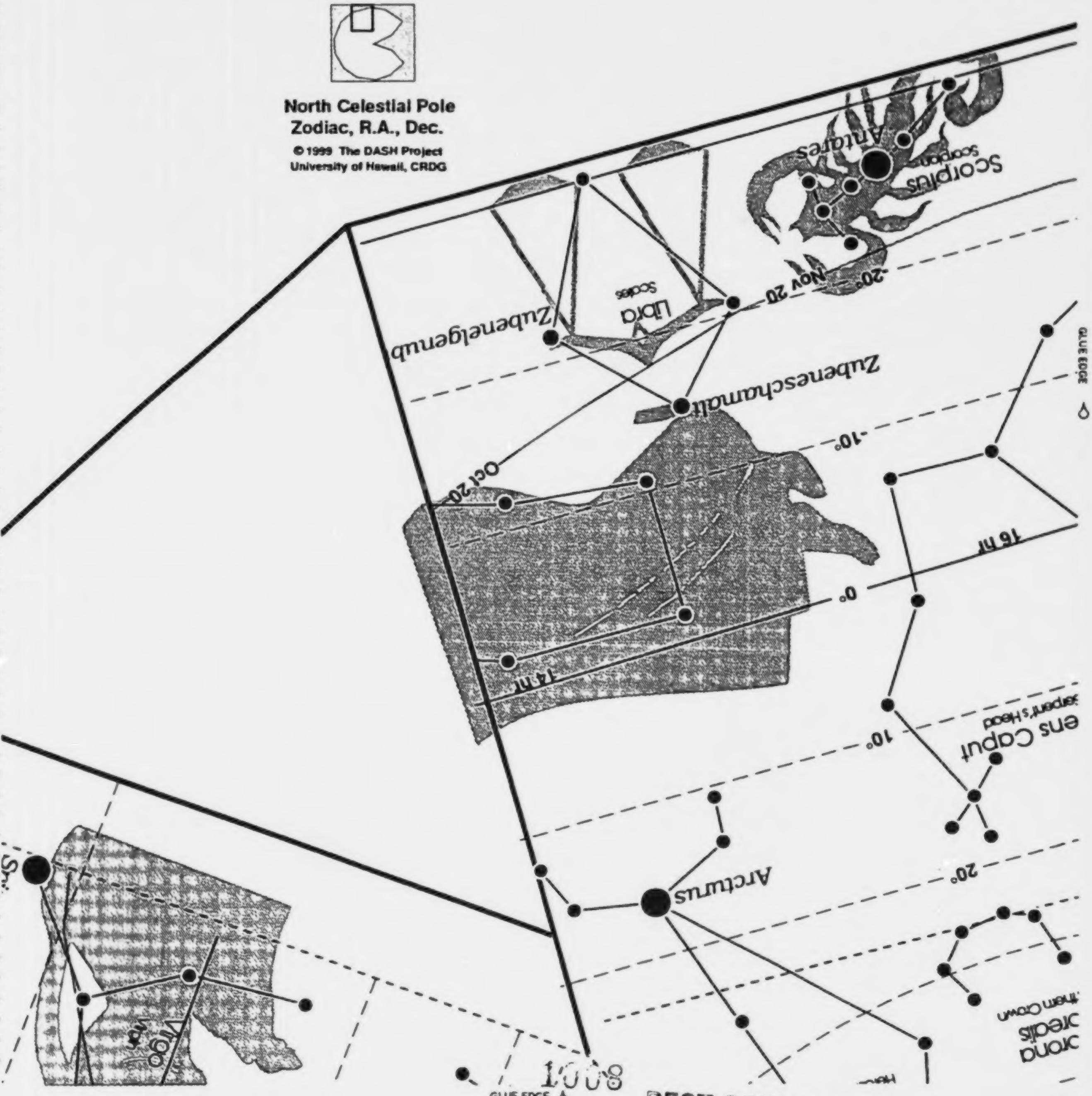
Scorpius
Scorpion
Antares
Libra
Scales
Zubenelgenubi
Zubeneschamali
Nov 20
Oct 20
-20°
-10°
0°
10°
20°
16 hr
14 hr
ens Caput
Serpent's Head
Arcturus
orona
orealis
thern Crown
Virgo
GLUE EDGE

GLUE EDGE

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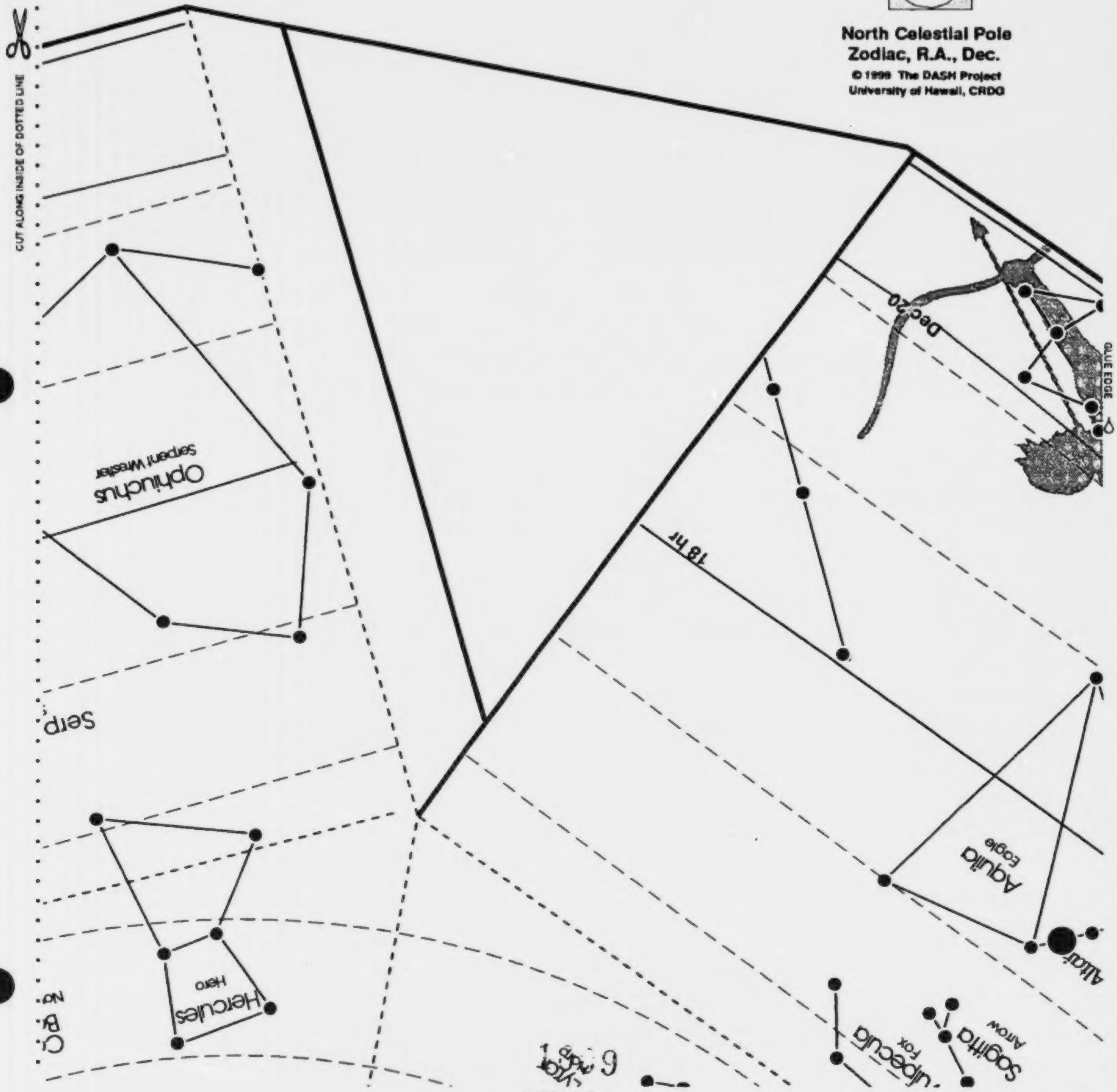
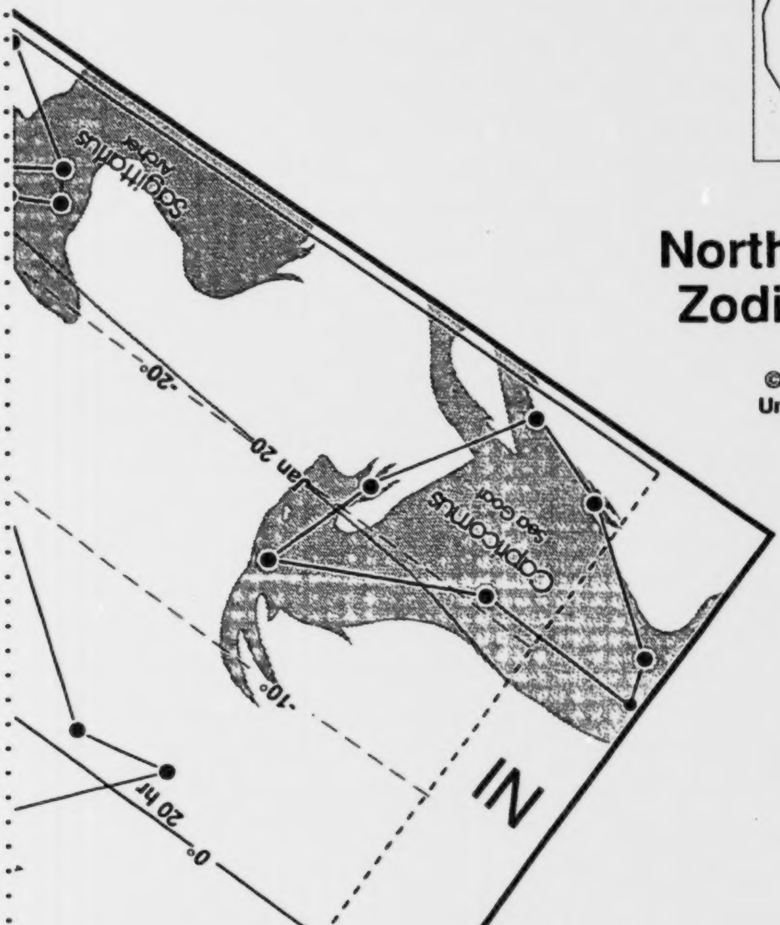

CUT ALONG INSIDE OF DOTTED LINE
Ophiuchus
Serpent Wrestler
Serp
Hercules
Hero
Dec 20
18 hr
GLUE EDGE
Aquila
Eagle
Altair
Sagitta
Arrow
Vulpecula
Fox
Lyra
GLUE EDGE

CUT ALONG INSIDE OF DOTTED LINE


Sagittarius
Archer
-20°
Jan 20
Capricornus
Sea Goat
-10°
IN
20 hr
0°
10°
© Univ

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North Celestial Pole Zodiac, R.A., Dec.

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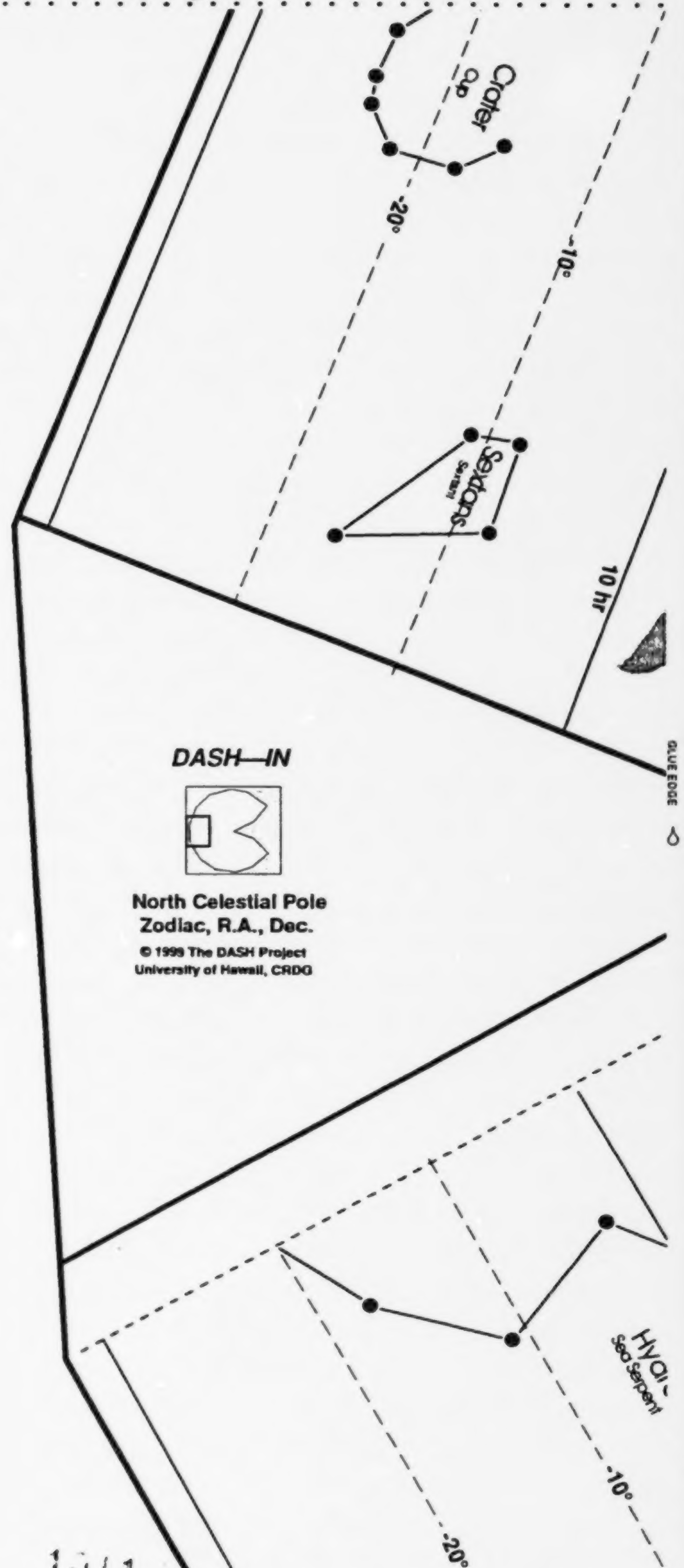
GLUE EDGE


Crater
Cup
-20°
-10°
Sextans
Sextant
10 hr
GLUE EDGE
Hydra
Sea Serpent
-10°
-20°
GLUE EDGE

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Zodiac, R.A., Dec.

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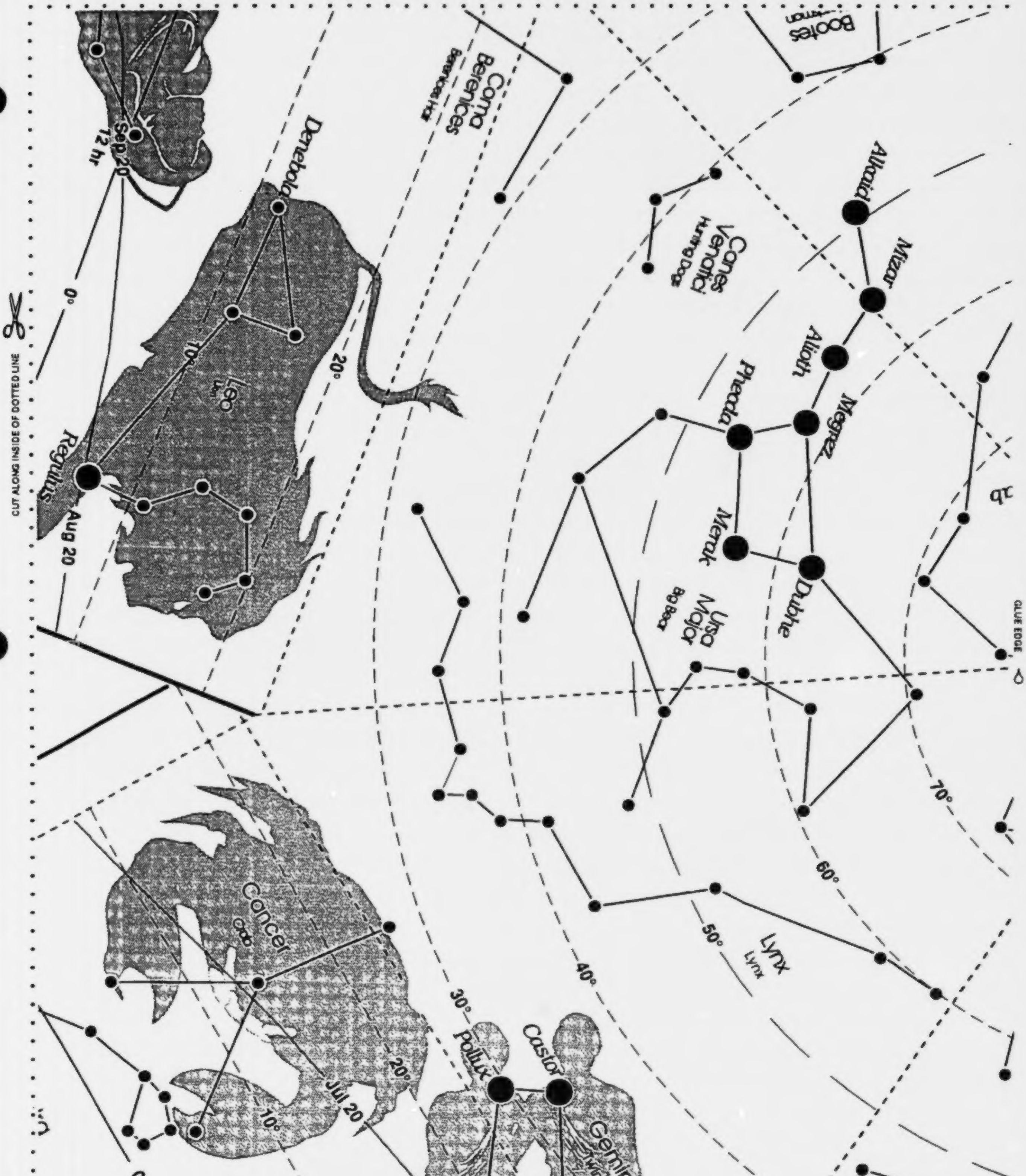
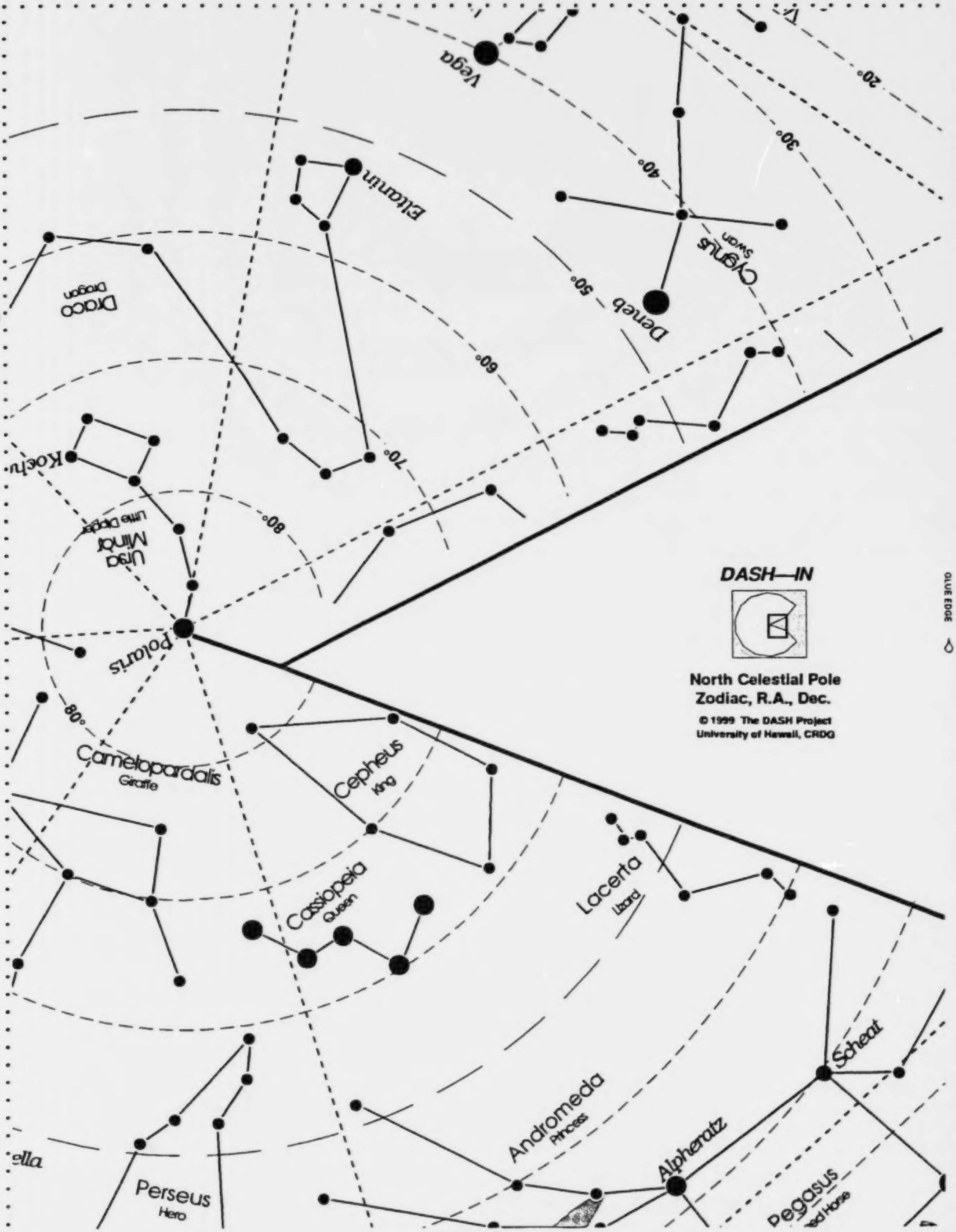

CUT ALONG INSIDE OF DOTTED LINE
Bootes
Coma Berenices
Berenice's Hair
Denebola
Sep 20
12 hr
Alkaid
Mizar
Canes Venatici
Hunting Dogs
Alioth
Phecda
Megrez
Leo
Lion
Regulus
Aug 20
Merak
Dubhe
Ursa Major
Big Bear
GLUE EDGE
0°
10°
20°
30°
40°
50°
60°
70°
Lynx
Lynx
Cancer
Crab
Pollux
Castor
Gemini
Twins
Jul 20
Canis Minor
Little Dog
08 hr
Cap
Auriga

GLUE EDGE

BEST COPY AVAILABLE

CUT ALONG INSIDE OF DOTTED LINE


Vega
20°
30°
40°
Eltanin
Cygnus
Swan
Draco
Dragon
Deneb
50°
60°
Koch
70°
Ursa
Minor
Little Dipper
80°
Polaris
80°
Camelopardalis
Giraffe
Cepheus
King
Lacerta
Lizard
Cassiopeia
Queen
Scheat
Andromeda
Princess
ella
Alpheratz
Perseus
Hero
Pegasus
ed Horse

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Zodiac, R.A., Dec.

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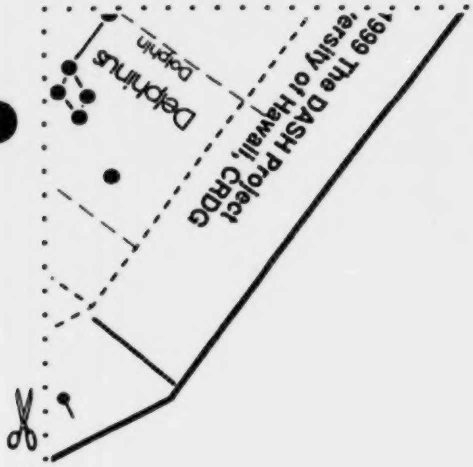
GLUE EDGE ◊

GLUE EDGE ◊


Delphinus
Delphin
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ersity of Hawaii, CRDG

CUT ALONG INSIDE OF DOTTED LINE

DASH—IN

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Zodiac, R.A., Dec.

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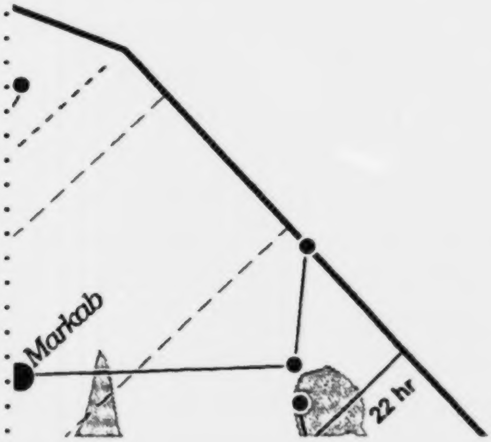

Markab
22 hr

GLUE EDGE

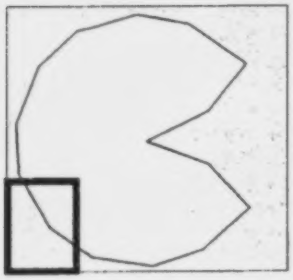
1014

CUT ALONG INSIDE OF DOTTED LINE

Canis Major
Big Dog

GLUE EDGE

DASH—IN



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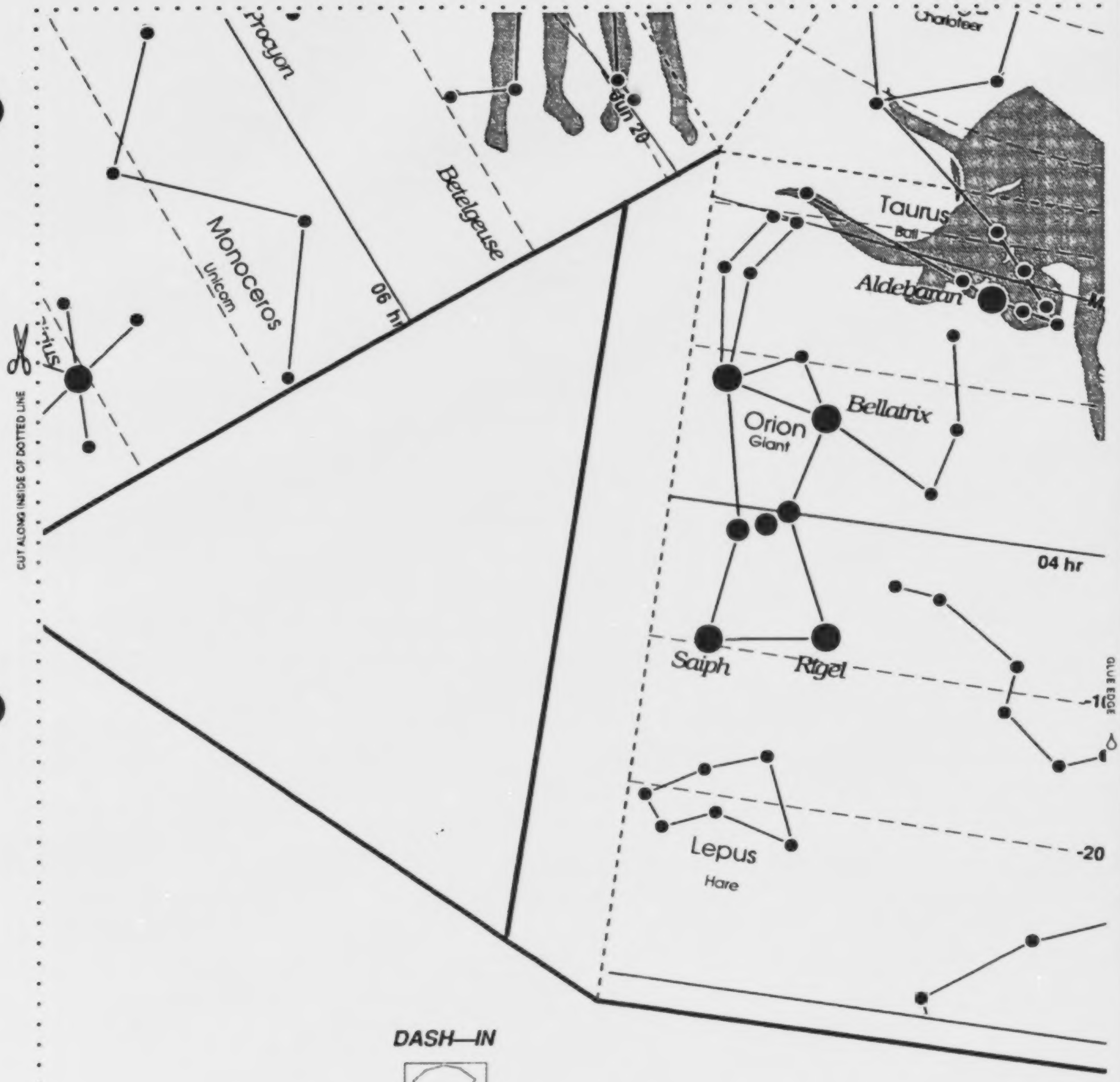
Procyon
Charioteer
Sun 20
Betelgeuse
Monoceros
Unicorn
06 hr
Sirius
CUT ALONG INSIDE OF DOTTED LINE
Taurus
Bull
Aldebaran
Orion
Giant
Bellatrix
04 hr
Saiph
Rigel
-10
Lepus
Hare
-20
GLUE EDGE

DASH—IN

North Celestial Pole
Zodiac, R.A., Dec.

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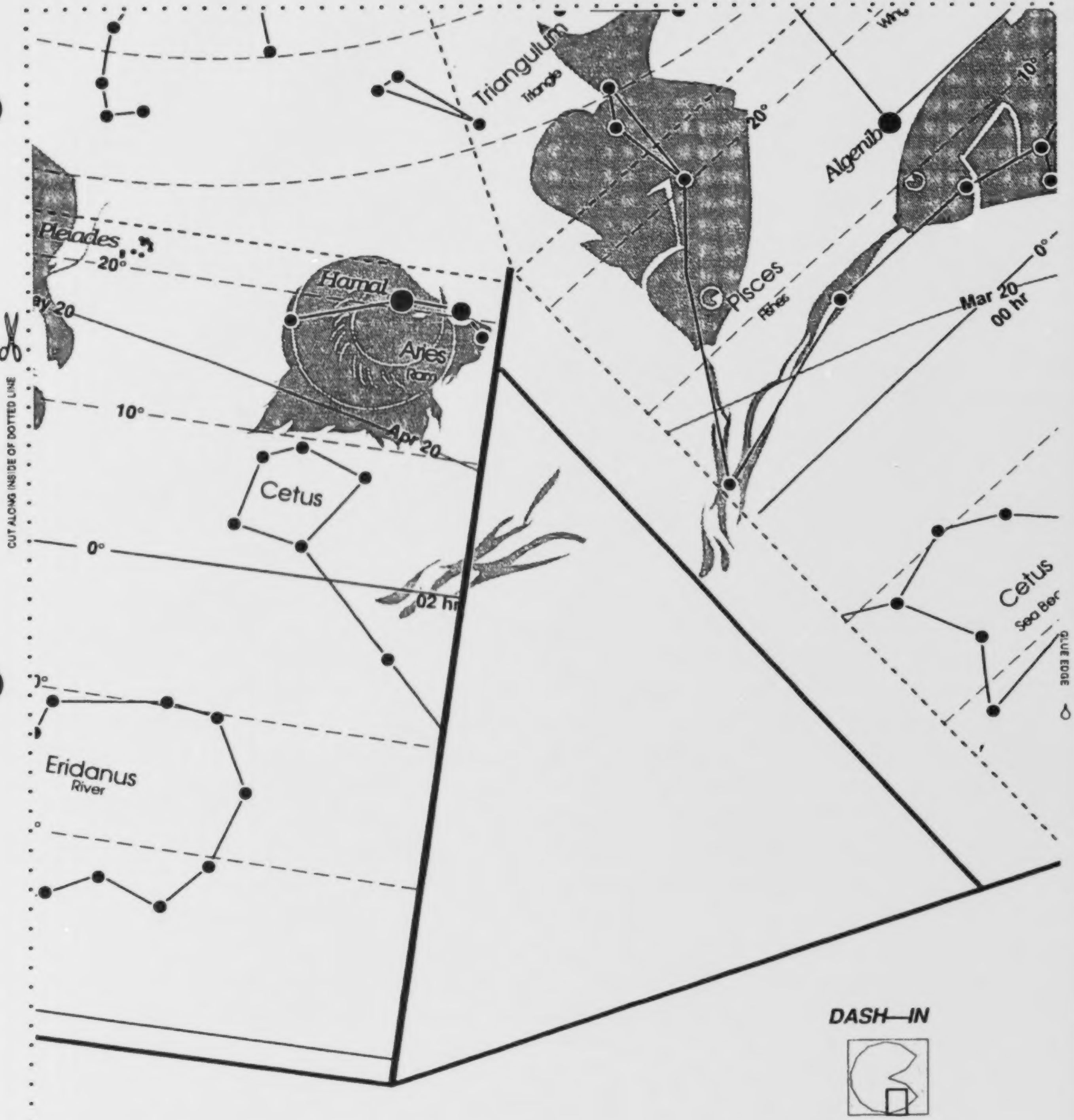
CUT ALONG INSIDE OF DOTTED LINE
Triangulum
Triangle
Pleiades
20°
Hamal
ay 20
Aries
Ram
10°
Apr 20
Cetus
0°
02 hr
Eridanus
River
Pisces
Fishes
Algenib
20°
10°
0°
Mar 20
00 hr
Cetus
Sea Bea
GLUE EDGE

DASH—IN

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Zodiac, R.A., Dec.

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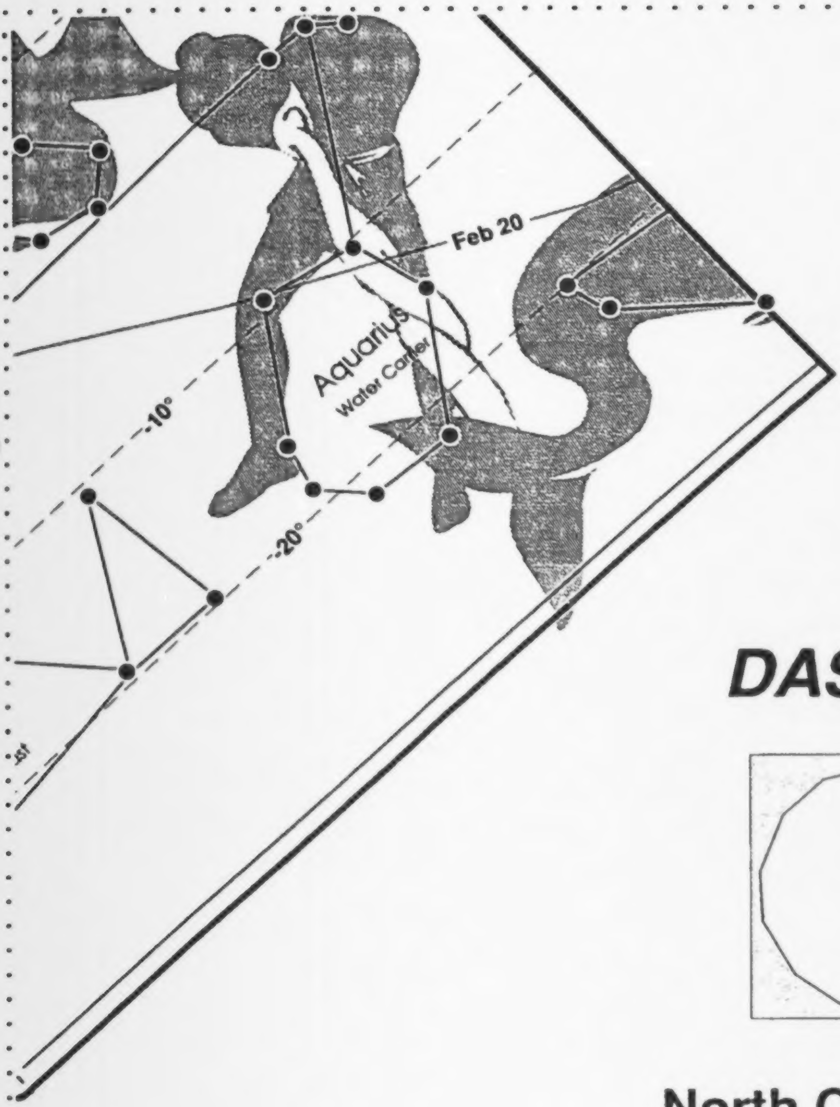
Feb 20
Aquarius
Water Carrier
-10°
-20°

CUT ALONG INSIDE OF DOTTED LINE

DASH—IN

North Celestial Pole
Zodiac, R.A., Dec.

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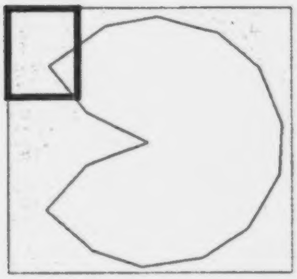
DASH—OUT



North Celestial Pole
Zodiac, R.A., Dec.

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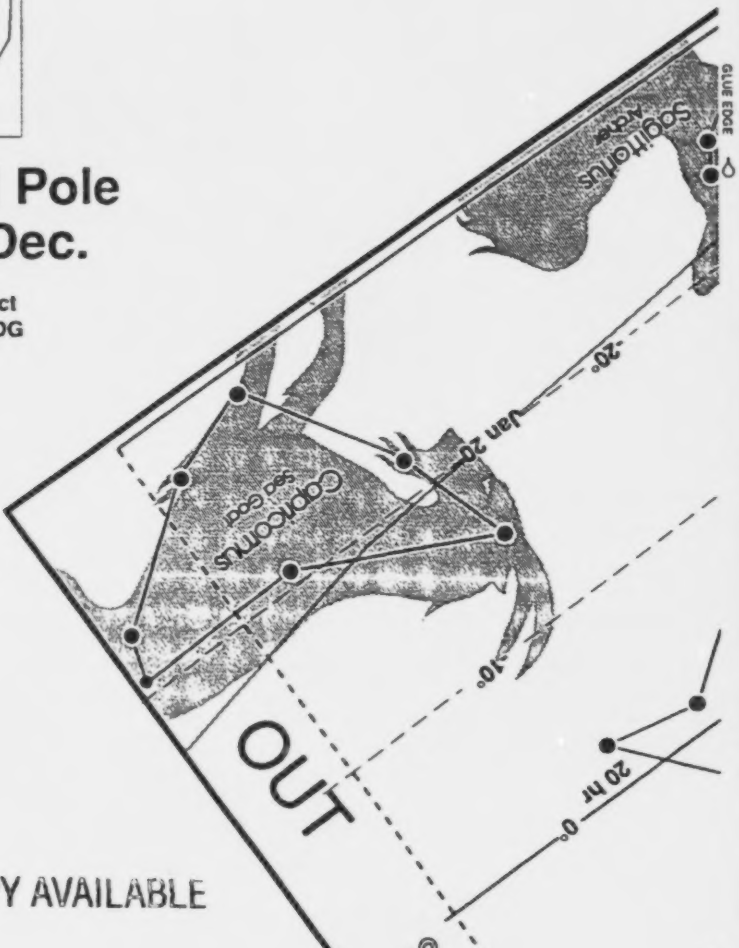
GLUE EDGE
Sagittarius
Archer
Capricornus
Sea Goat
Jan 20
-20°
-10°
0°
20 hr
OUT

BEST COPY AVAILABLE

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North Celestial Pole
Zodiac, R.A., Dec.

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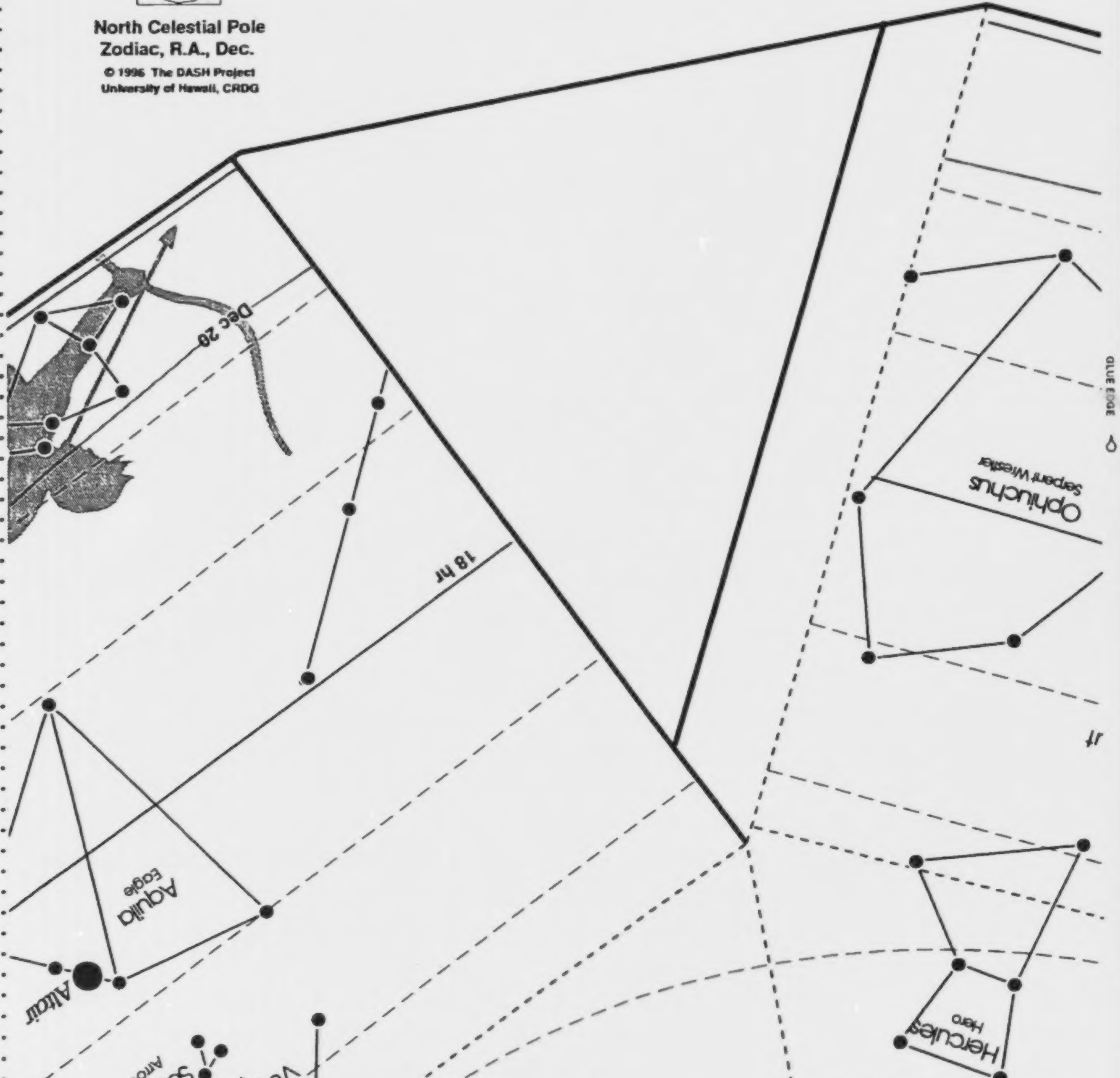
CUT ALONG INSIDE OF DOTTED LINE


Dec 20
18 hr
Ophiuchus
Serpent Wrestler
Aquila
Eagle
Altair
Hercules
Hero
Sagitta
Arrow
Vulpecula
Fox
Lyra
Harp
10°
GLUE EDGE
GLUE EDGE

DASH—OUT

North Celestial Pole
Zodiac, R.A., Dec.

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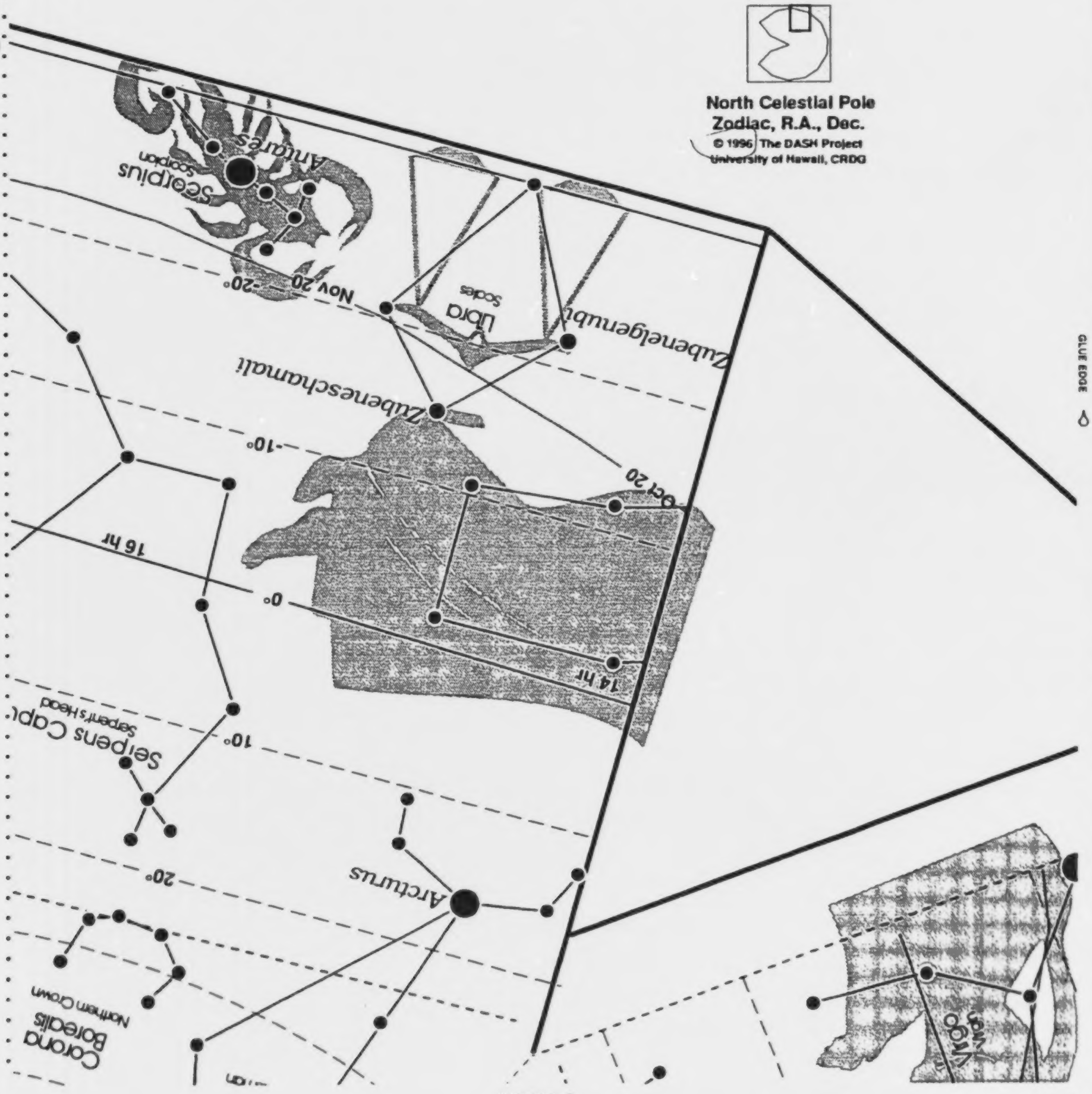
CUT ALONG INSIDE OF DOTTED LINE


Scorpius
Scorpion
Antares
Libra
Scales
Zubenelgenubi
Zubeneschamali
Nov 20
Oct 20
-20°
-10°
0°
10°
20°
16 hr
14 hr
Serpens Caput
Serpent's Head
Arcturus
Corona Borealis
Northern Crown
Virgo

GLUE EDGE

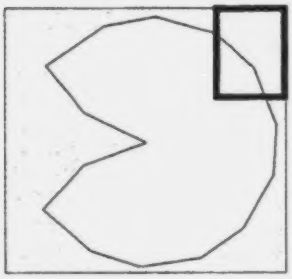
GLUE EDGE

1.12***

BEST COPY AVAILABLE

CUT ALONG INSIDE OF DOTTED LINE

DASH—OUT



North Celestial Pole
Zodiac, R.A., Dec.

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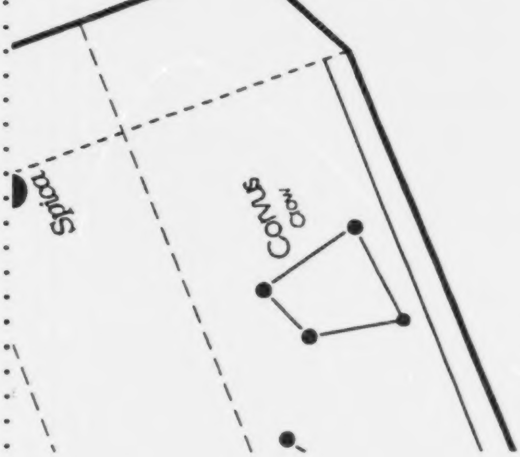
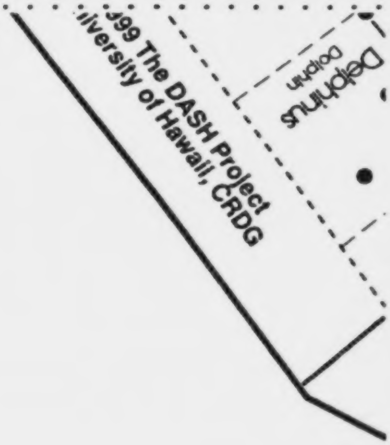

Spica
Corvus
Crow

GLUE EDGE 6

CUT ALONG INSIDE OF DOTTED LINE


999 The DASH Project
iversity of Hawaii, CRDG
Delphinus
Dolphin

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Zodiac, R.A., Dec.

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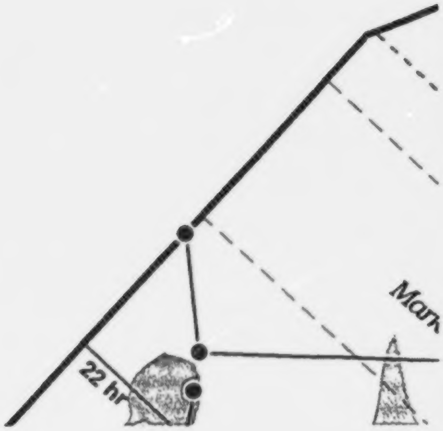
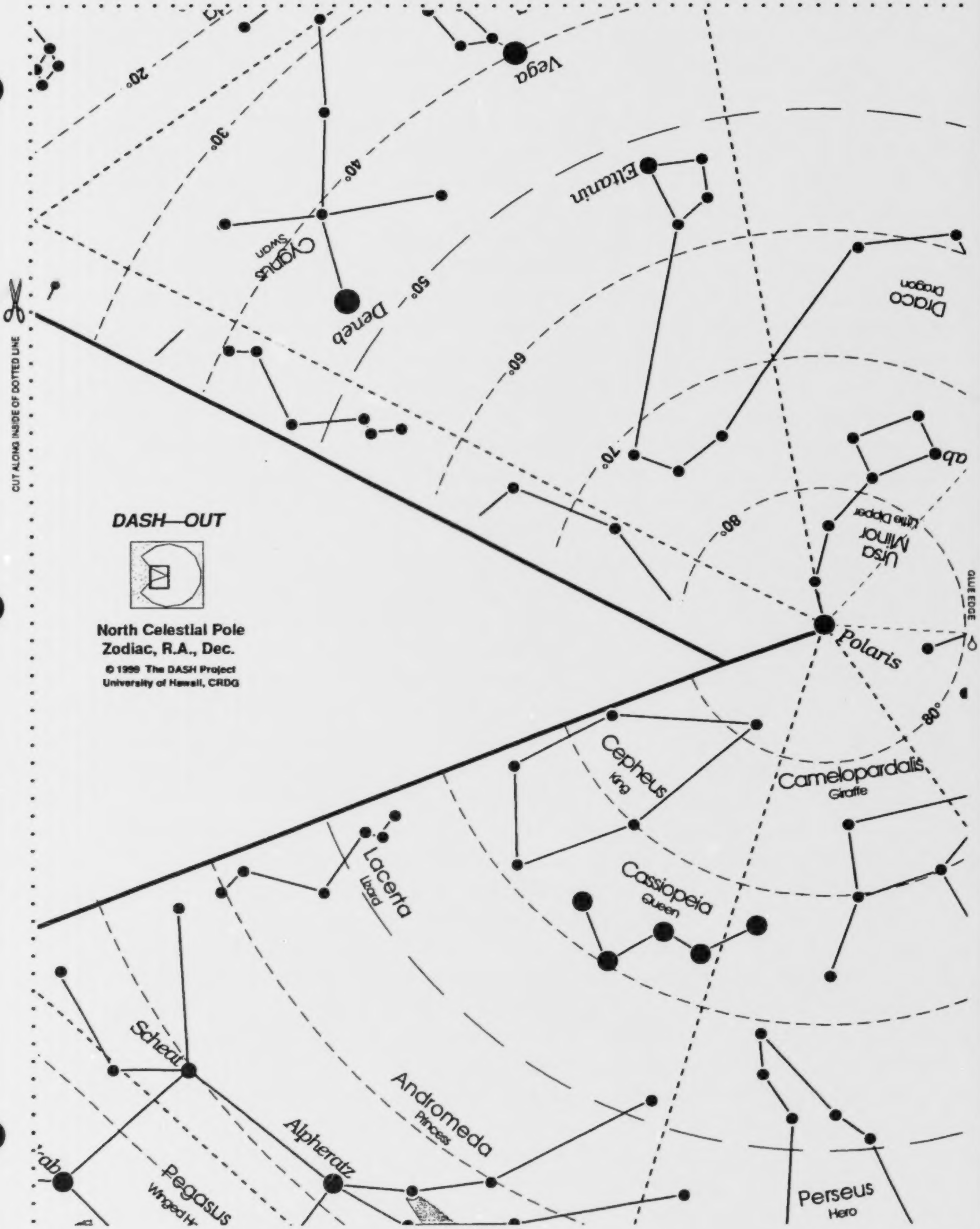
GLUE EDGE



GLUE EDGE

1.12***


20°
30°
40°
50°
60°
70°
80°
80°
Vega
Eltanin
Cygnus
Swan
Deneb
Draco
Dragon
Ursa
Minor
Little Dipper
Polaris
Cepheus
King
Camelopardalis
Giraffe
Cassiopeia
Queen
Lacerta
Lizard
Andromeda
Princess
Alpheratz
Scheat
Pegasus
Winged H
Perseus
Hero
CUT ALONG INSIDE OF DOTTED LINE
GLUE EDGE
GLUE EDGE

DASH—OUT

North Celestial Pole
Zodiac, R.A., Dec.

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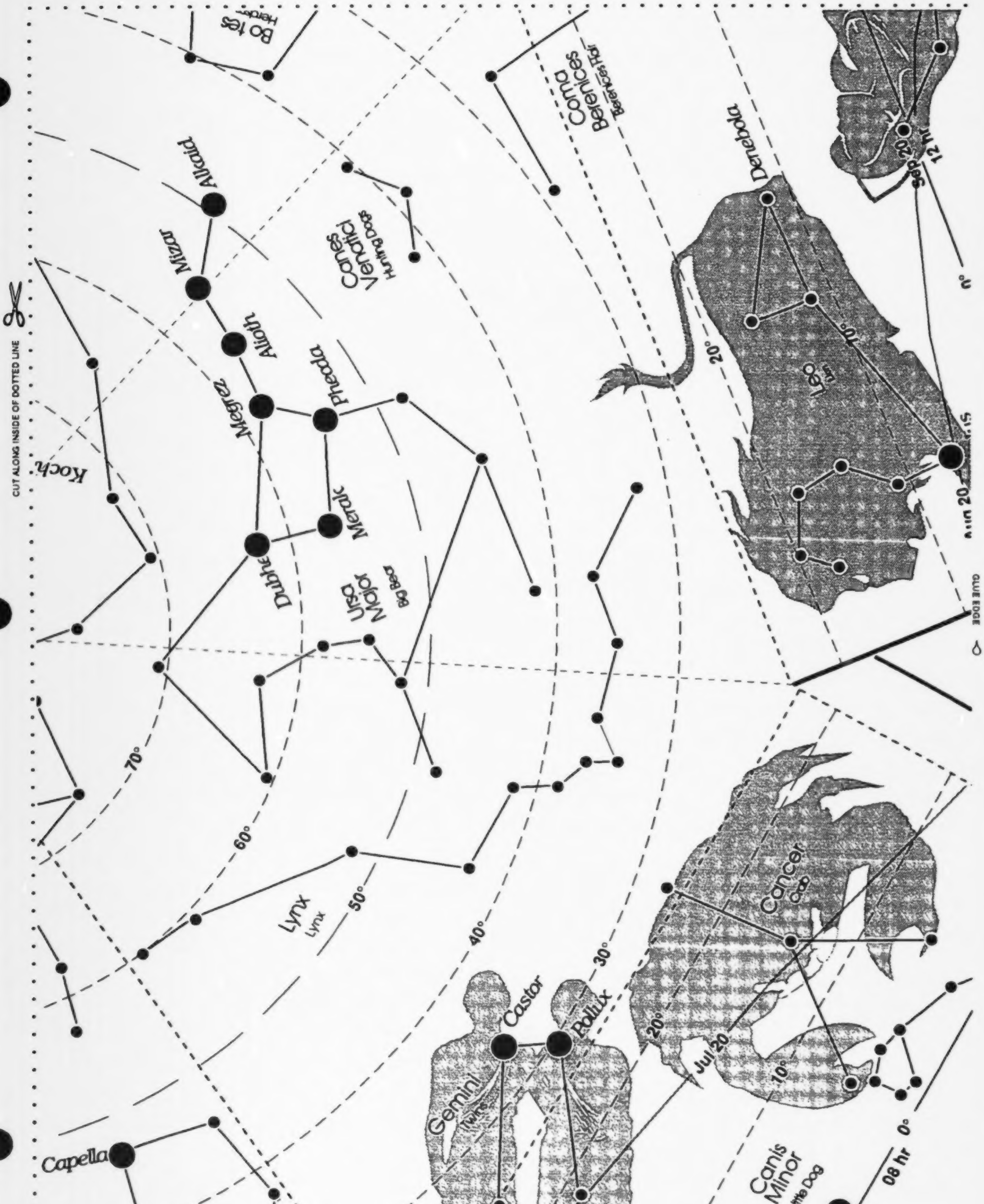
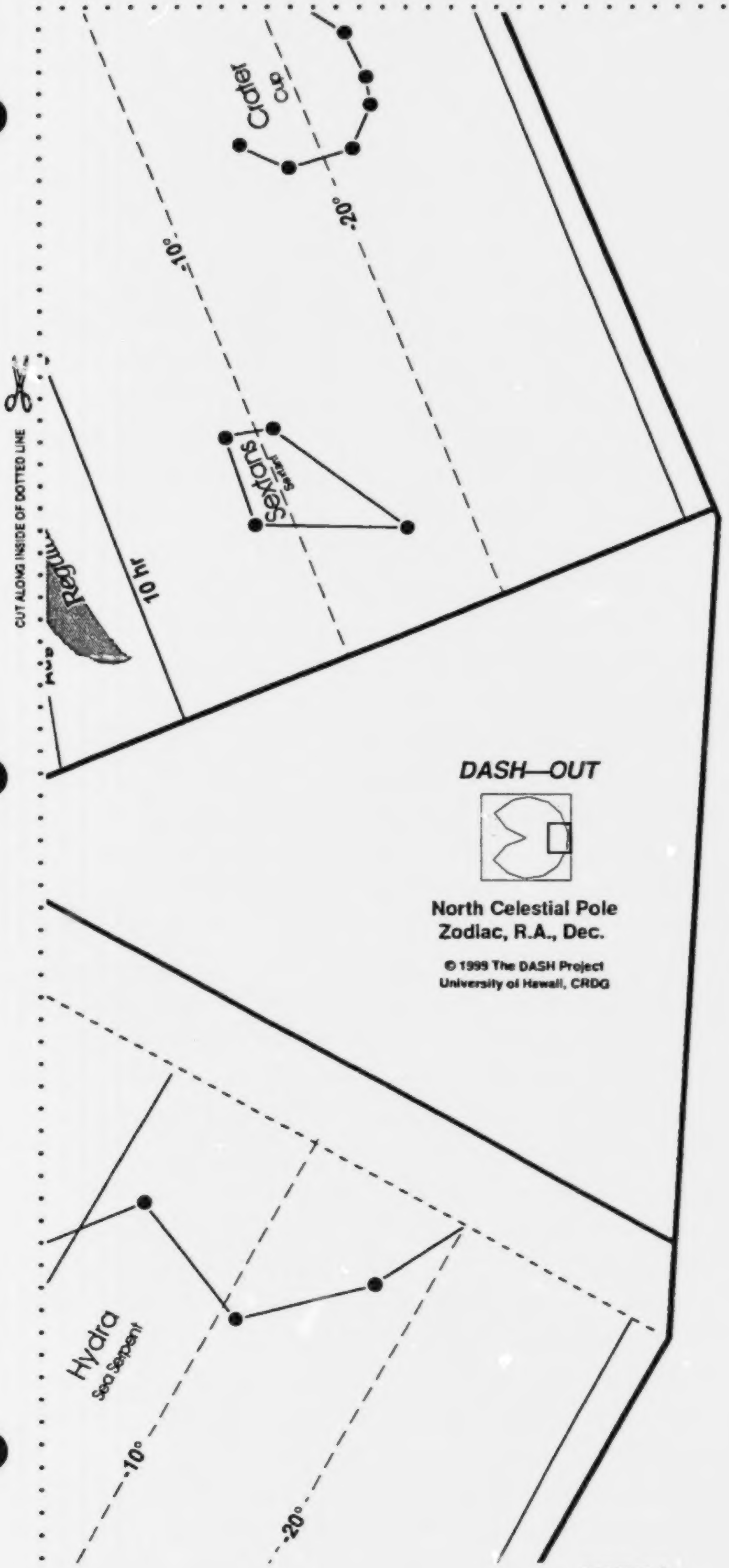

Boötes
Herdsman
Coma Berenices
Berenice's Hair
Denebola
Sep 20
12 hr
0°
Alkaid
Mizar
Alioth
Megrez
Phecda
Merak
Dubhe
Canes Venatici
Hunting Dogs
Ursa Major
Big Bear
Leo
Lion
20°
10°
Aug 20
GLUE EDGE
CUT ALONG INSIDE OF DOTTED LINE
Koch.
70°
60°
50°
40°
30°
Lynx
Lynx
Cancer
Crab
Castor
Pollux
Gemini
Twins
20°
Jul 20
10°
0°
08 hr
Canis Minor
Little Dog
Capella
Auriga
GLUE EDGE

BEST COPY AVAILABLE 1.12***


Crater
Cup
-20°
-10°
Sextans
Sextant
CUT ALONG INSIDE OF DOTTED LINE
Regulus
10 hr
Hydra
Sea Serpent
-10°
-20°
GLUE EDGE

DASH—OUT

North Celestial Pole
Zodiac, R.A., Dec.

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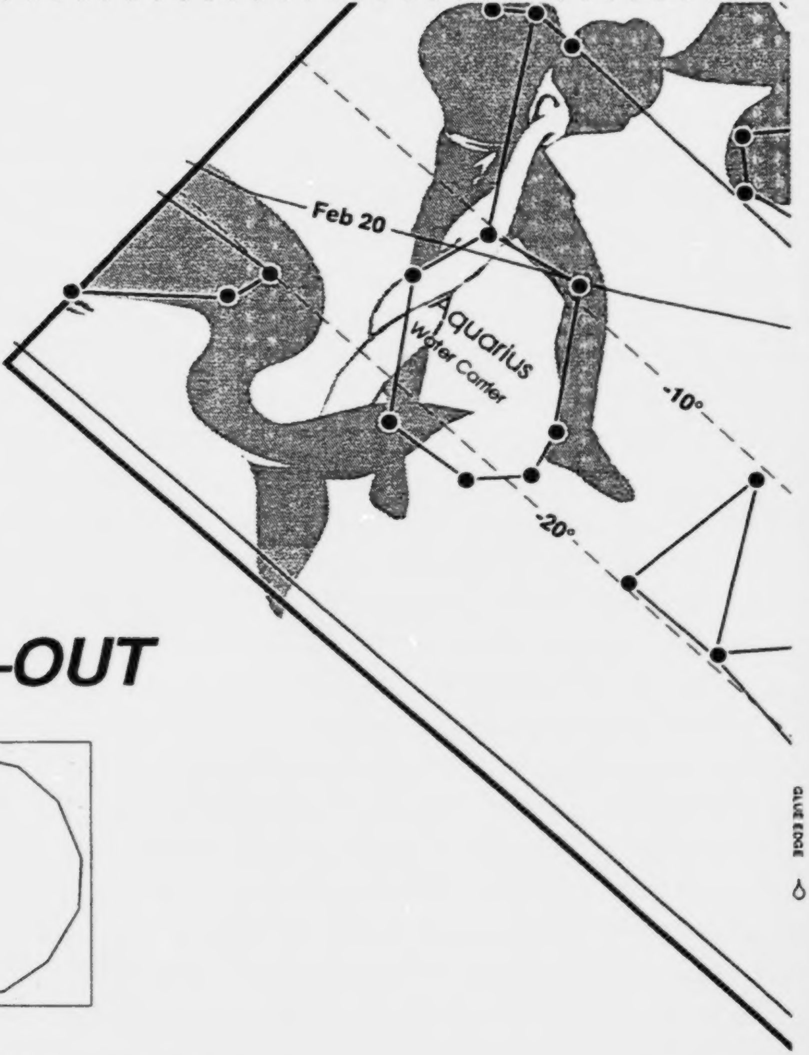
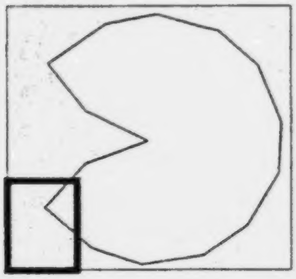
CUT ALONG INSIDE OF DOTTED LINE


Feb 20
Aquarius
Water Carrier
-10°
-20°

GLUE EDGE

DASH—OUT



North Celestial Pole
Zodiac, R.A., Dec.

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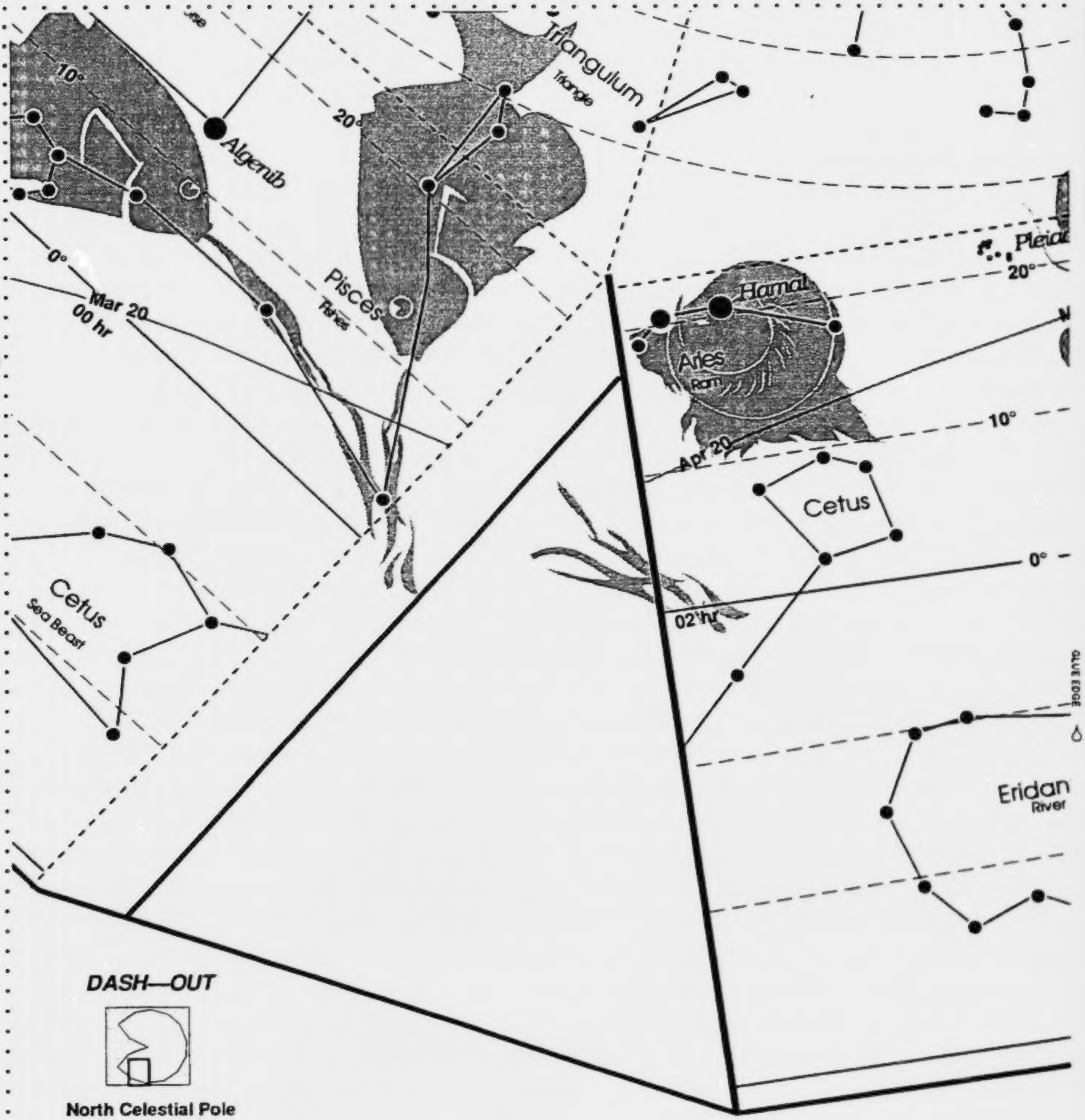
1027


Triangulum
Triangle
Algenib
10°
20°
0°
Mar 20
00 hr
Pisces
Fishes
Pleiad
20°
Hamal
Aries
Ram
10°
Apr 20
Cetus
0°
02 hr
Cetus
Sea Beast
Eridan
River

CUT ALONG INSIDE OF DOTTED LINE

GLUE EDGE

DASH—OUT

North Celestial Pole
Zodiac, R.A., Dec.

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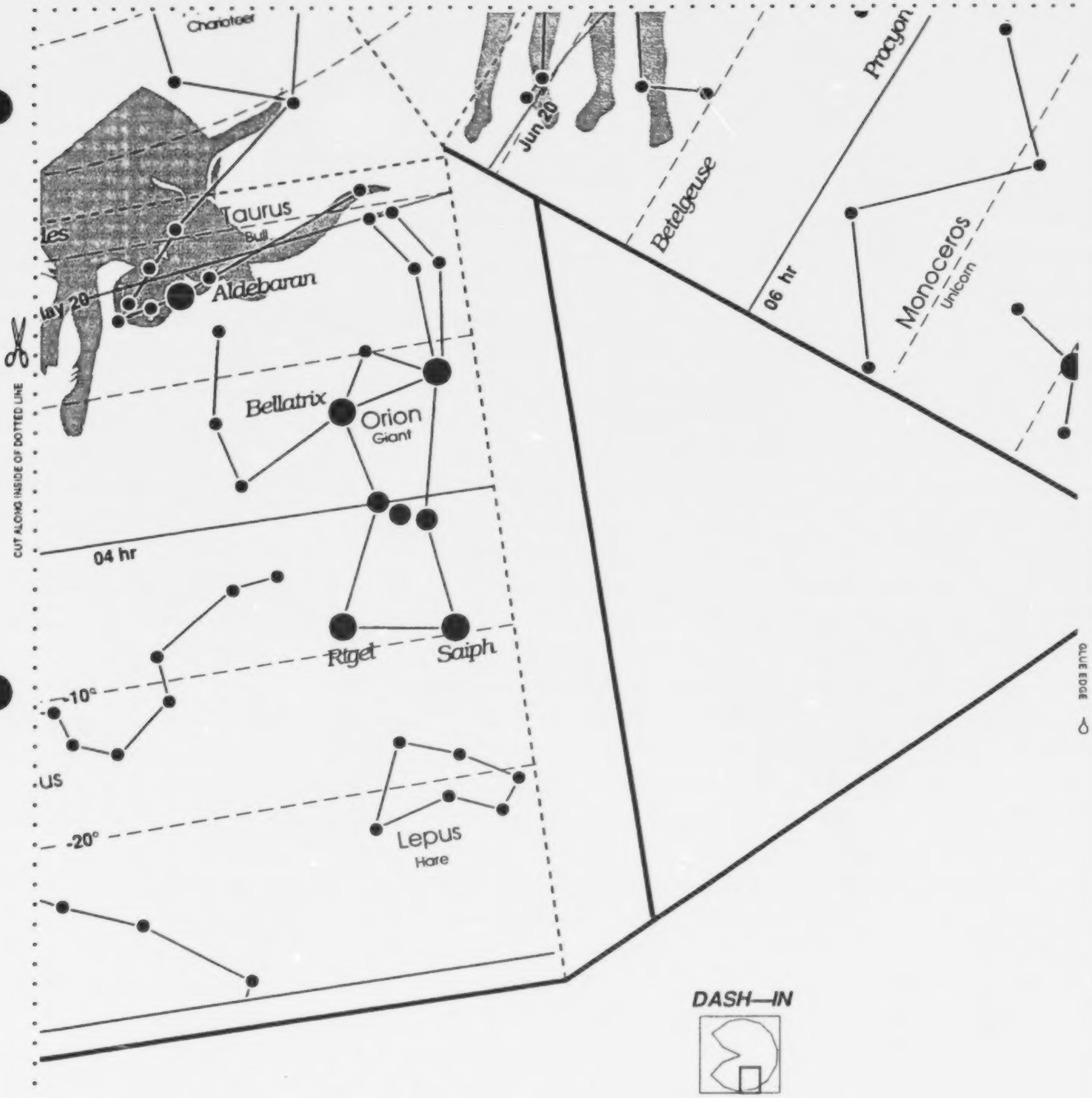
Charioteer
Jun 20
Betelgeuse
Procyon
les
Taurus
Bull
Aldebaran
lay 20
06 hr
Monoceros
Unicorn
CUT ALONG INSIDE OF DOTTED LINE
Bellatrix
Orion
Giant
04 hr
Rigel
Saiph
-10°
GLUE EDGE
us
-20°
Lepus
Hare

DASH—IN

North Celestial Pole
Zodiac, R.A., Dec.

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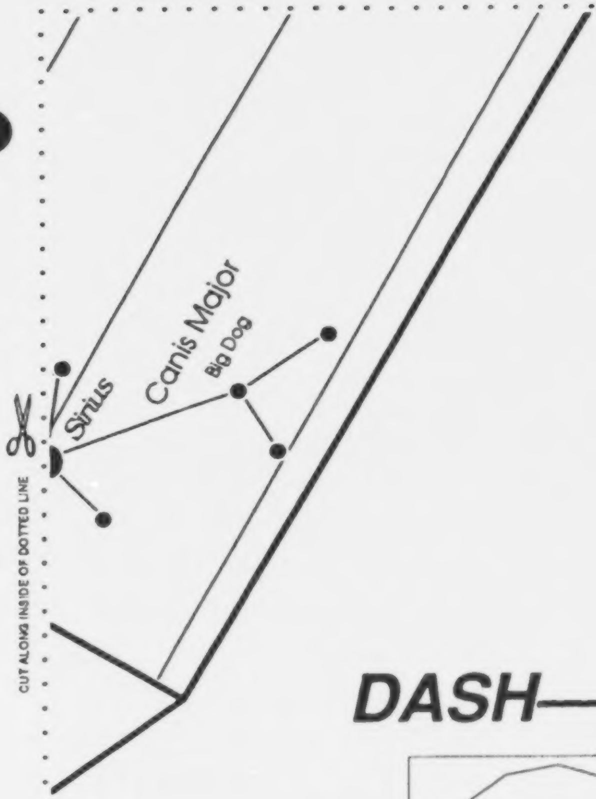
Sirius
Canis Major
Big Dog
CUT ALONG INSIDE OF DOTTED LINE

DASH—OUT

North Celestial Pole
Zodiac, R.A., Dec.

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DASH

Name______________________________

Date______________________________

STUDENT PAGE 5.7.2C ZODIACAL CONSTELLATIONS

Table 5.7.2 Zodiacal constellations and the sun

ZODIACAL CONSTELLATION	*DATES WHEN SUN IS IN THE CONSTELLATION
Capricornus, the Goat	January 19–February 15
Aquarius, the Water Bearer	February 16–March 11
Pisces, the Fishes	March 12–April 18
Aries, the Ram	April 19–May 13
Taurus, the Bull	May 14–June 20
Gemini, the Twins	June 21–July 19
Cancer, the Crab	July 20–August 9
Leo, the Lion	August 10–September 15
Virgo, the Virgin	September 16–October 30
Libra, the Balance	October 31–November 22
Scorpius, the Scorpion	November 23–December 17
Sagittarius, the Archer	December 18–January 18

*Adjust for Leap Years

1. Explain what we mean when we say that the sun is "in" a certain constellation.

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2. Explain how you would orient your Planetarium when you are observing at night.

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DASH

Name__________________________

Date__________________________

STUDENT PAGE 5.7.3A MAPPING THE SKY

1. Assemble the model of Earth found in Figure SP 5.7.3A(1). *Cut* along the dark lines and *fold* along the dotted lines.

2. Cut out the center of the clock-face rings in Figures SP 5.7.3A(2–3). Color the interval between 0600 hours and 1800 hours *yellow* to indicate daylight. Glue the rings back to back with a sheet of plastic wrap sandwiched between. Trim off excess plastic wrap.

3. Explain how the longitude and latitude coordinates of Earth maps are similar to declination and right ascension (R.A.) coordinates on sky maps.

4. From its coordinates how do you find a star on the Planetarium, for example, a star with an R.A. of 11 hr 10 min and a declination of 57°?

Name ______________________________

5. **Explain how the *Barry's Wayfinding* doggerel can help find coordinates on Earth.**

6. **Explain how the *Barry in Space* doggerel can help find coordinates in space.**

DASH

Name ______________________

Date ______________________

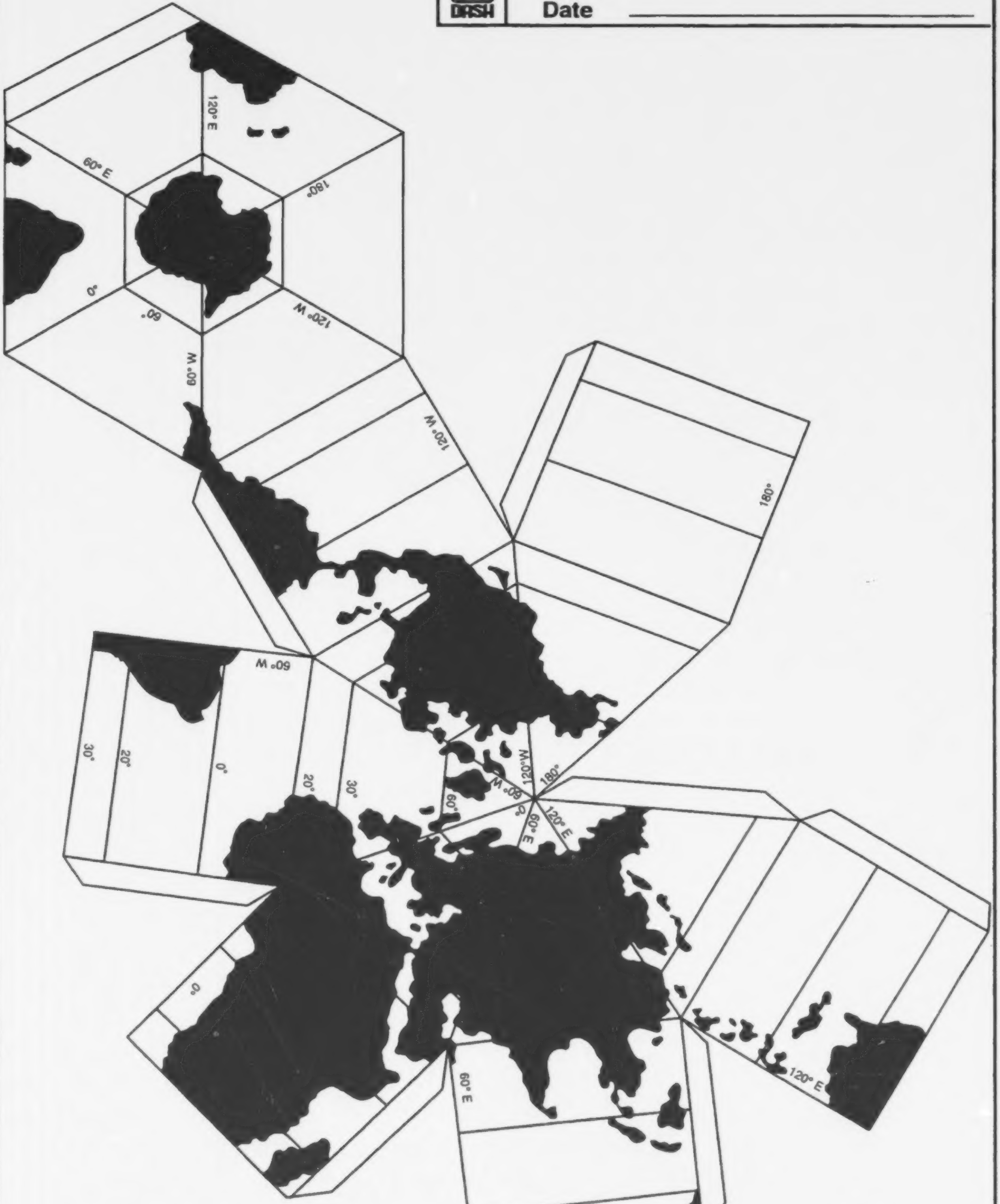
120° E
60° E
180°
0°
60°
120° W
60° W
120° W
180°
60° W
30°
20°
0°
20°
30°
120°W
180°
60° W
60°
0°
60° E
120° E
0°
60° E
120° E

Figure SP 5.7.3A(1) Model of the Earth showing latitude and longitude

Name ______________________________

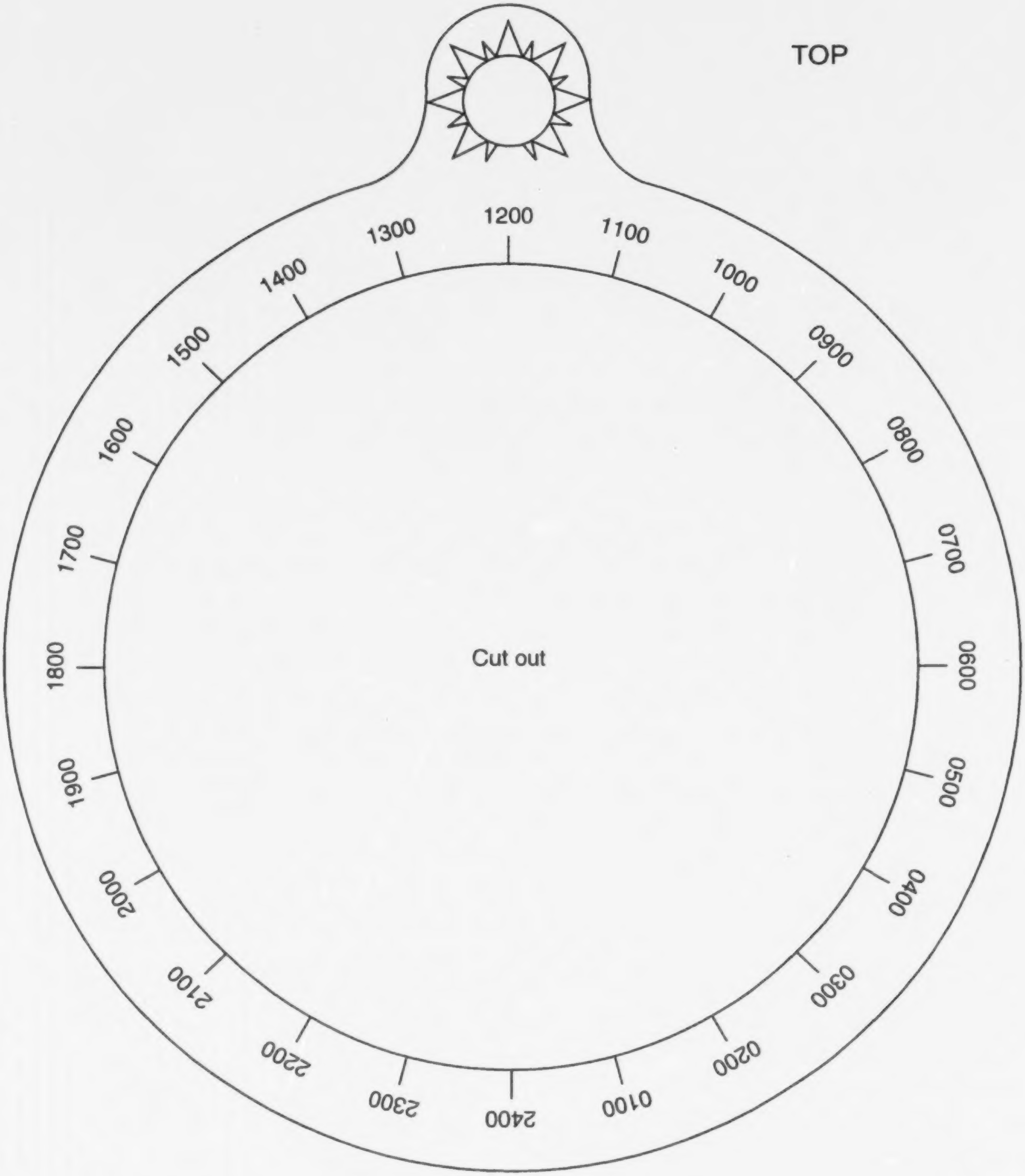
TOP
1200
1100
1000
0900
0800
0700
0600
0500
0400
0300
0200
0100
2400
2300
2200
2100
2000
1900
1800
1700
1600
1500
1400
1300
Cut out

Figure SP 5.7.3A(2) Top clock-face ring

Name ______________________________

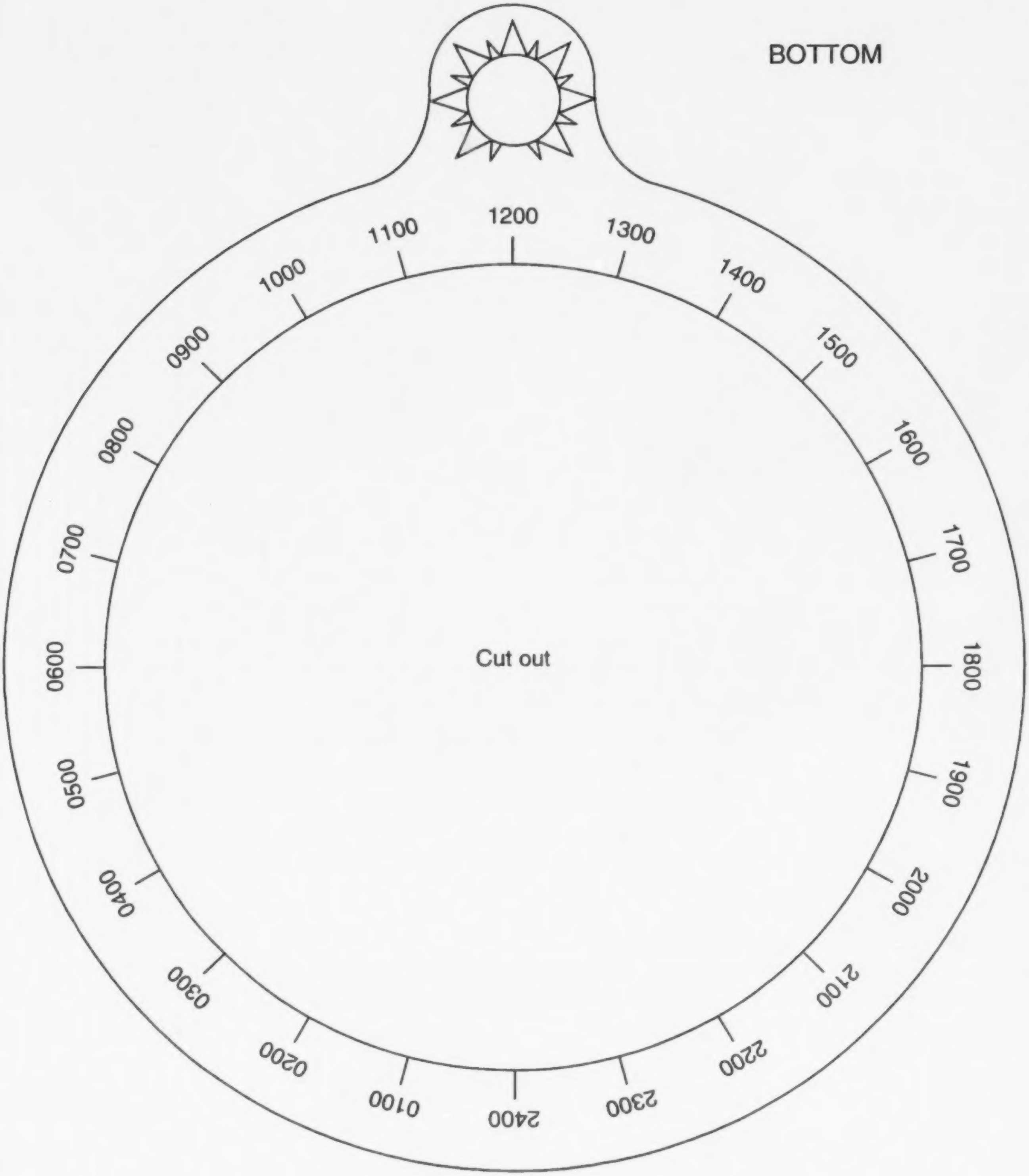
BOTTOM
1200
1300
1400
1500
1600
1700
1800
1900
2000
2100
2200
2300
2400
0100
0200
0300
0400
0500
0600
0700
0800
0900
1000
1100
Cut out

Figure SP 5.7.3A(3) Bottom clock-face ring

DASH

Name____________________________

Date____________________________

STUDENT PAGE 5.7.3B
BARRY'S WAYFINDING: LONGITUDE AND LATITUDE

BARRY'S WAYFINDING

There once was an explorer called Barry
Who a map refused to carry.
When he got lost,
A coin he'd toss,
But he'd wind up in places quite scary.

Coordinates he decided to learn
So he would always make the right turn.
The latitude line
Was easy to find
At night when he made a sojourn.

He would simply find the North Polar Star.
Then with his fists he'd measure how far
Above the horizon it lies
In the northern night skies.
Ten times his fists gave the latitude bar.

Longitude was no harder to find
For it he needed only Greenwich time.
For every degree
Is 4 minutes you see
Of difference from this prime time line.

His watch at Greenwich he'd set
At local noon the difference he'd get.
Dividing the minutes by 4,
He'd shout with a roar
The longitude so he wouldn't forget.

Now there's a lesson in this
And it's one that is hard to resist.
When the North Star's height
And Greenwich time unite
On Earth you'll always know where you exist.

DASH

Name____________________________

Date_____________________________

STUDENT PAGE 5.7.3C
BARRY IN SPACE: DECLINATION AND RIGHT ASCENSION

BARRY IN SPACE

Oh, Barry got hooked on the stars
And decided to take a group up to Mars,
But how would they find
A place of this kind
When in space in their long rocket cars?

A map of the heavens Barry found
And he spread it out on the ground.
"Aha!" he said.
"This is easily read.
It's like all the other maps around.

"Look, like Earth, it's got an equator
And Polaris' 90° is our orientater.
Declination we'll find
On the meridian line
And use our fist as a degree calculator.

"For example, let's take a star that's bright.
Betelgeuse is brilliant at night.
Plus 10° its declination
Six hours its right ascension
Are the coordinates that we will write.

"Now, each fist from the Pole Star dot
Is 10 degrees from 90 on the declination plot.
Eight fists down
What have we found?
Heaven's equator is 10 degrees from the spot.

Name ______________________________

"We can see from this simple operation
What I mean by the similar relation.
How finding magnitude
Of our Earth's latitude
Is like finding the heavens' declination.

"That leads us to our right ascension.
Finding that's almost too easy to mention.
Twenty-four hours it will take
For the heavens to make
A full circle by Ptolemaic convention.

"Here on the heavens' equator line
We look for the sixth hour of time,
And at the intersect,
As we would expect,
Betelgeuse is right there to find.

"To use the great circle of the equator
There is a natural space locator.
Between hours 5 and 6
We get our R.A. fix.
On Orion's Belt there's a three-star indicator."

"We're all ready to go," said Barry.
"Only a map and our fists we need carry.
An almanac too
Will give us a cue,
And finding Mars will never be scary."

DASH

Name________________________

Date________________________

STUDENT PAGE 5.7.4
NORTH POLE, EQUATOR, AND ECLIPTIC

1. Describe your demonstration of how a flashlight or overhead projector can be used to show the changing noon gnomon readings. Use diagrams as needed.

2. Figure SP 5.7.4(1) is a diagram showing three gnomons—one at Singapore, which is at 0° latitude, one at 23° N, and one at 23° S. You are looking east and the time is 1200 hours, solar noon. Shadow triangles produced at the time of the equinoxes and solstices are shown. Explain how the declination of the sun can be read directly from the gnomon angle at Singapore. Use diagrams as needed.

Name ______________________________

3. **Explain how the Singapore gnomon data on the graph in Figure SP 5.7.4(2) helps us trace the path of the sun through the Zodiacal Band.**

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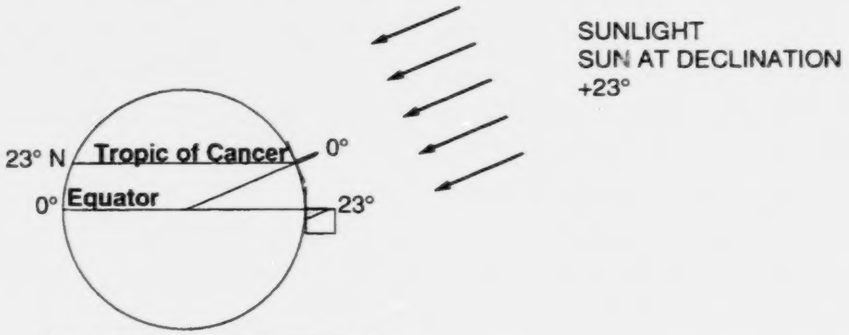
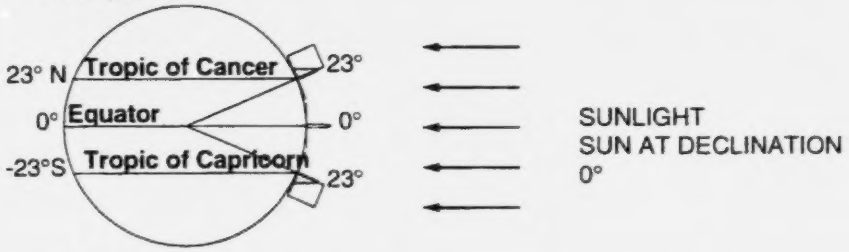
ILLUSTRATIONS

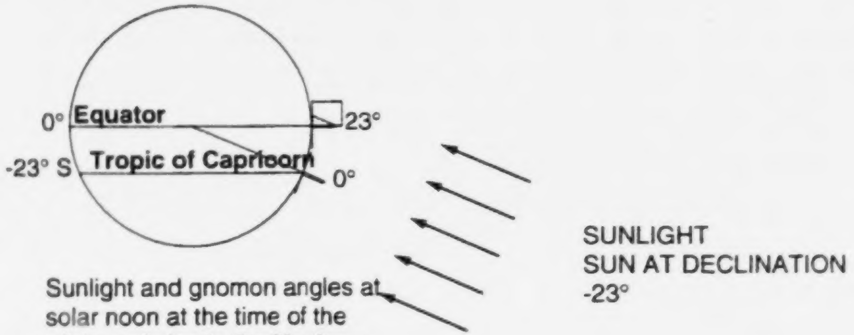
Name ______________________________


23° N
Tropic of Cancer
0°
0°
Equator
23°
SUNLIGHT
SUN AT DECLINATION
+23°

Sunlight and gnomon angles at solar noon at the time of the summer solstice in the Northern Hemisphere


23° N
Tropic of Cancer
23°
0°
Equator
0°
-23°S
Tropic of Capricorn
23°
SUNLIGHT
SUN AT DECLINATION
0°

Sunlight and gnomon angles at solar noon at the time of the equinoxes


0°
Equator
23°
-23° S
Tropic of Capricorn
0°
SUNLIGHT
SUN AT DECLINATION
-23°

Sunlight and gnomon angles at solar noon at the time of the winter solstice in the Northern Hemisphere

Figure SP 5.7.4(1) Sunlight on gnomons at 23° N, the equator (0°), and 23° S at solar noon at the solstices and equinoxes

Name ______________________________

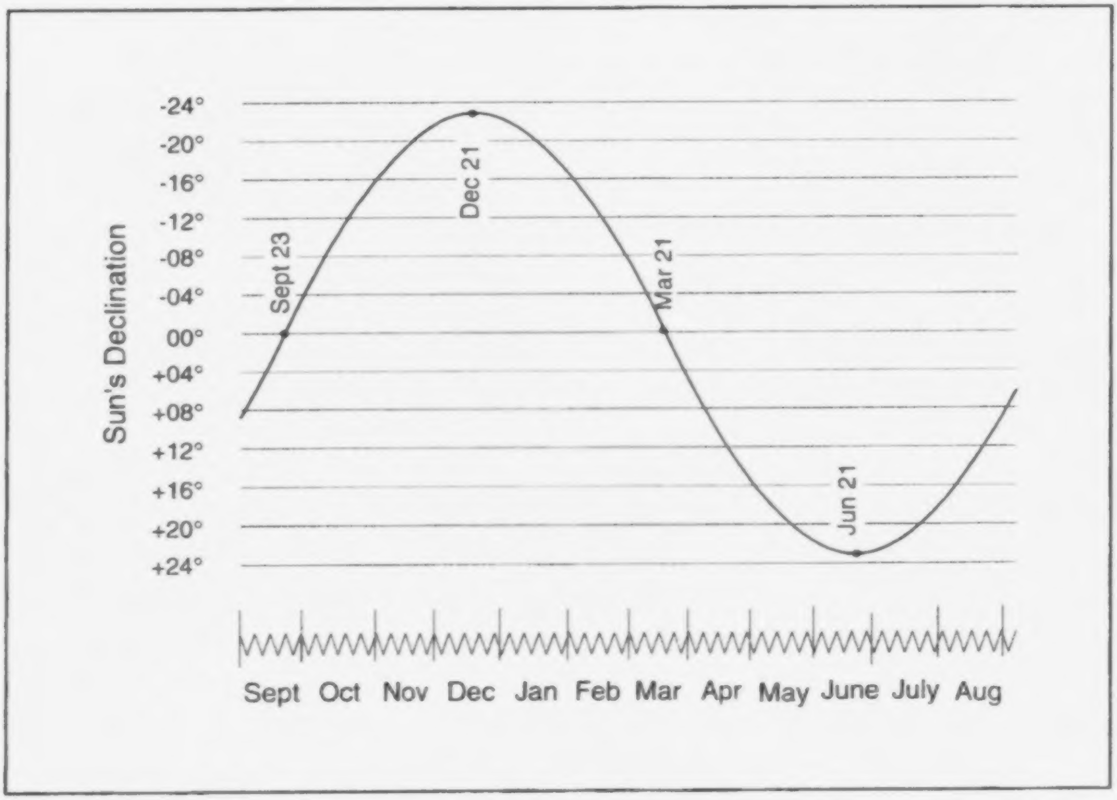


Figure SP 5.7.4(2) Graph of a gnomon's local noon shadows at Singapore over a 12-month period. Recorded in degrees of declination.

DASH

Name____________________________

Date____________________________

STUDENT PAGE 5.7.5 WHERE IS EARTH?

1. Construct a pushpin-and-pencil model of the sun, Earth, and Zodiacal Band. Use Figures SP 5.7.5(1–3).

2. As an observer looking down from above the North Star, describe how Earth rotates on its axis.

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3. As an observer looking down from above the North Star, describe Earth's revolution about the sun.

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4. Assemble Earth's orbital ring and four Earth models. See Figure SP 5.7.5(4).

5. Explain how the sun appears to travel in the path of the ecliptic through the Zodiacal Band.

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Name ______________________________

6. Assemble a model to show Earth's seasonal lighting by the sun. See Figure SP 5.7.5(5). Explain how Earth's path along the ecliptic produces seasons.

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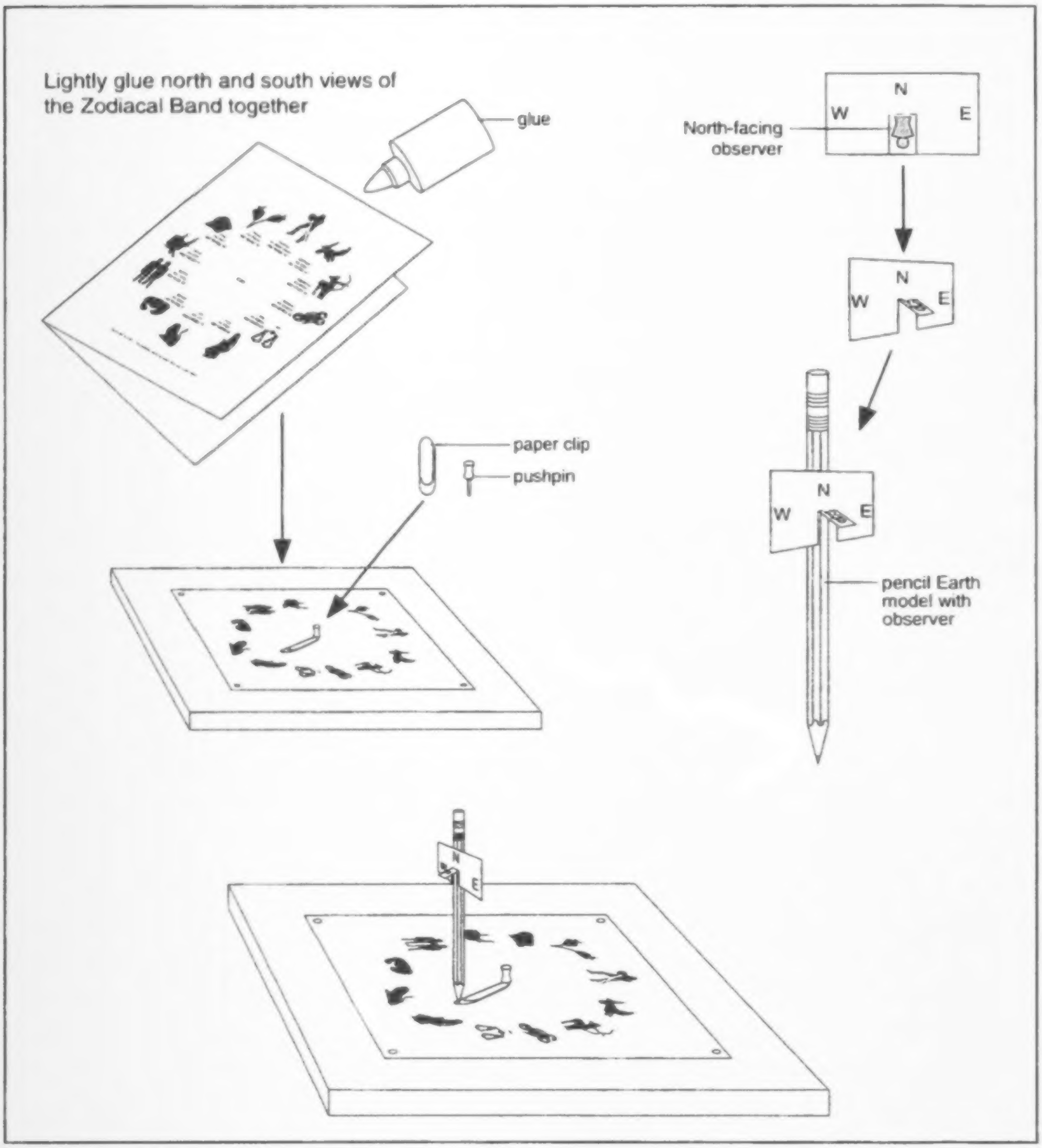
ILLUSTRATIONS

Name ______________________________


Lightly glue north and south views of the Zodiacal Band together

glue
North-facing observer
N
W
E
paper clip
pushpin
pencil Earth model with observer

Figure SP 5.7.5(1) Construction of a push-pin-and-pencil model of the sun, Earth, and Zodiacal Band

Name ______________________________

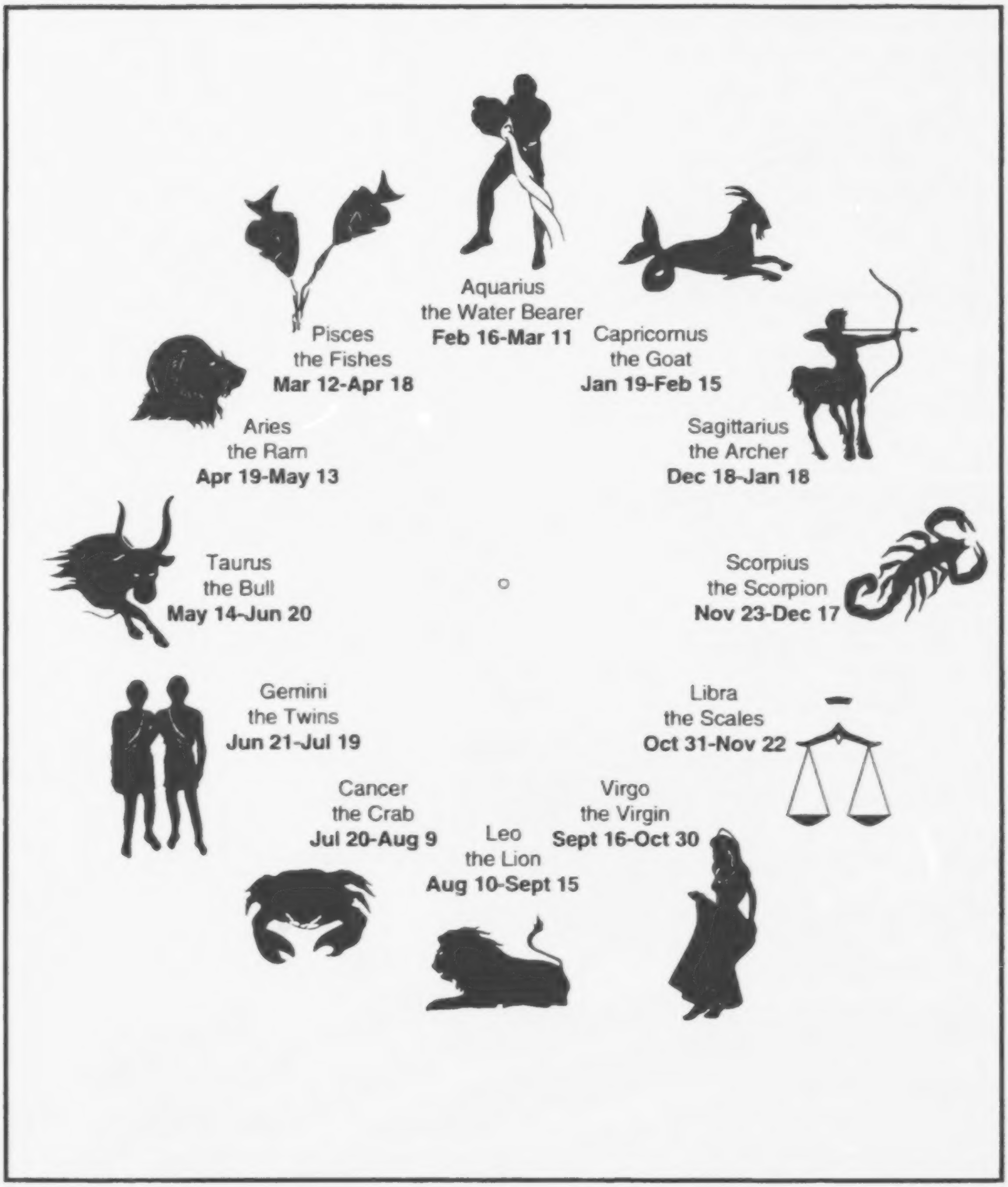

Aquarius
the Water Bearer
Feb 16-Mar 11
Pisces
the Fishes
Mar 12-Apr 18
Capricornus
the Goat
Jan 19-Feb 15
Aries
the Ram
Apr 19-May 13
Sagittarius
the Archer
Dec 18-Jan 18
Taurus
the Bull
May 14-Jun 20
Scorpius
the Scorpion
Nov 23-Dec 17
Gemini
the Twins
Jun 21-Jul 19
Libra
the Scales
Oct 31-Nov 22
Cancer
the Crab
Jul 20-Aug 9
Virgo
the Virgin
Sept 16-Oct 30
Leo
the Lion
Aug 10-Sept 15

Figure SP 5.7.5(2) The Zodiacal Band viewed looking down from the North Star

Name ______________________________

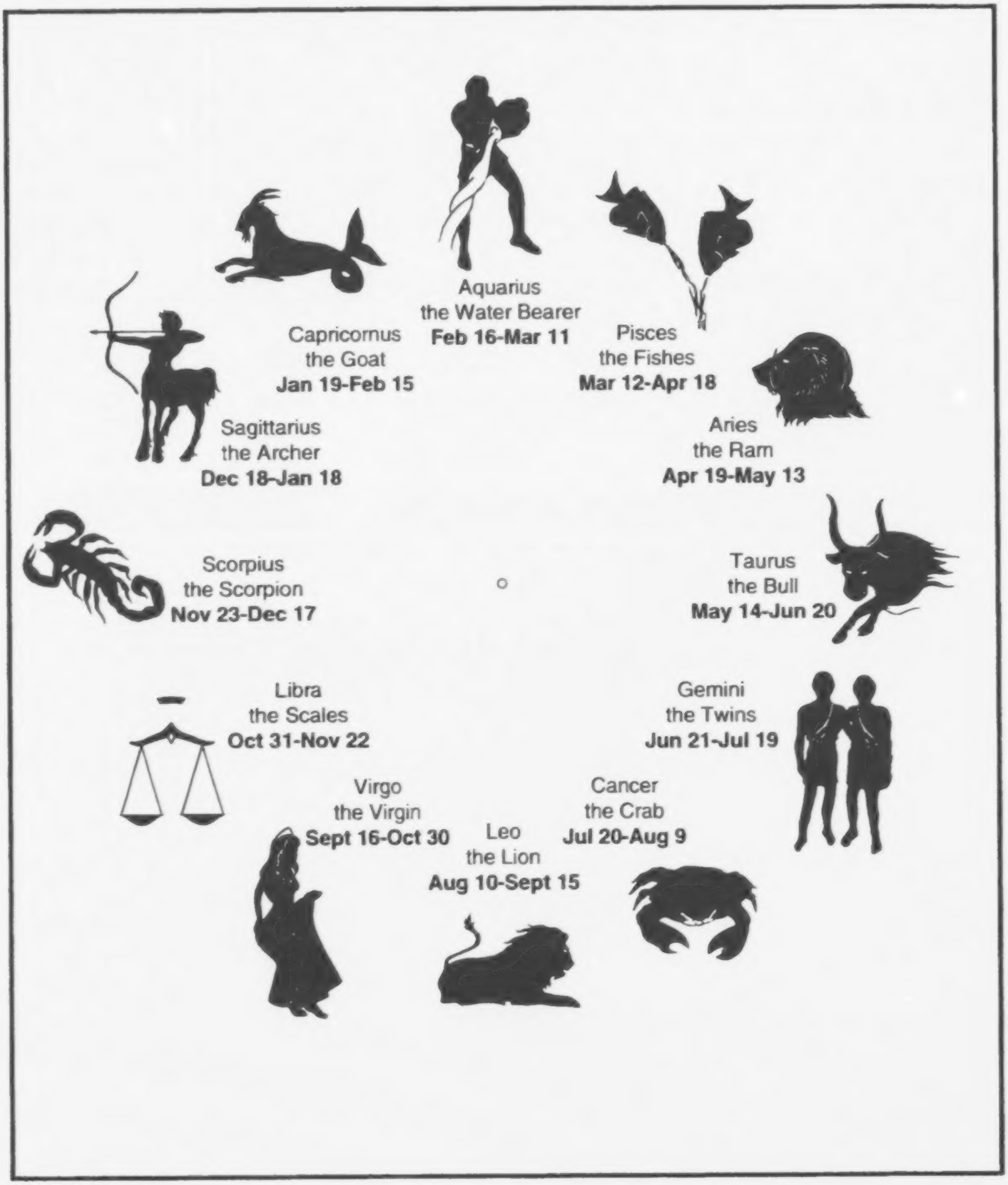

Aquarius
the Water Bearer
Feb 16-Mar 11
Capricornus
the Goat
Jan 19-Feb 15
Pisces
the Fishes
Mar 12-Apr 18
Sagittarius
the Archer
Dec 18-Jan 18
Aries
the Ram
Apr 19-May 13
Scorpius
the Scorpion
Nov 23-Dec 17
Taurus
the Bull
May 14-Jun 20
Libra
the Scales
Oct 31-Nov 22
Gemini
the Twins
Jun 21-Jul 19
Virgo
the Virgin
Sept 16-Oct 30
Cancer
the Crab
Jul 20-Aug 9
Leo
the Lion
Aug 10-Sept 15

Figure SP 5.7.5(3) The Zodiacal Band viewed looking up from the south

Name ________________________________

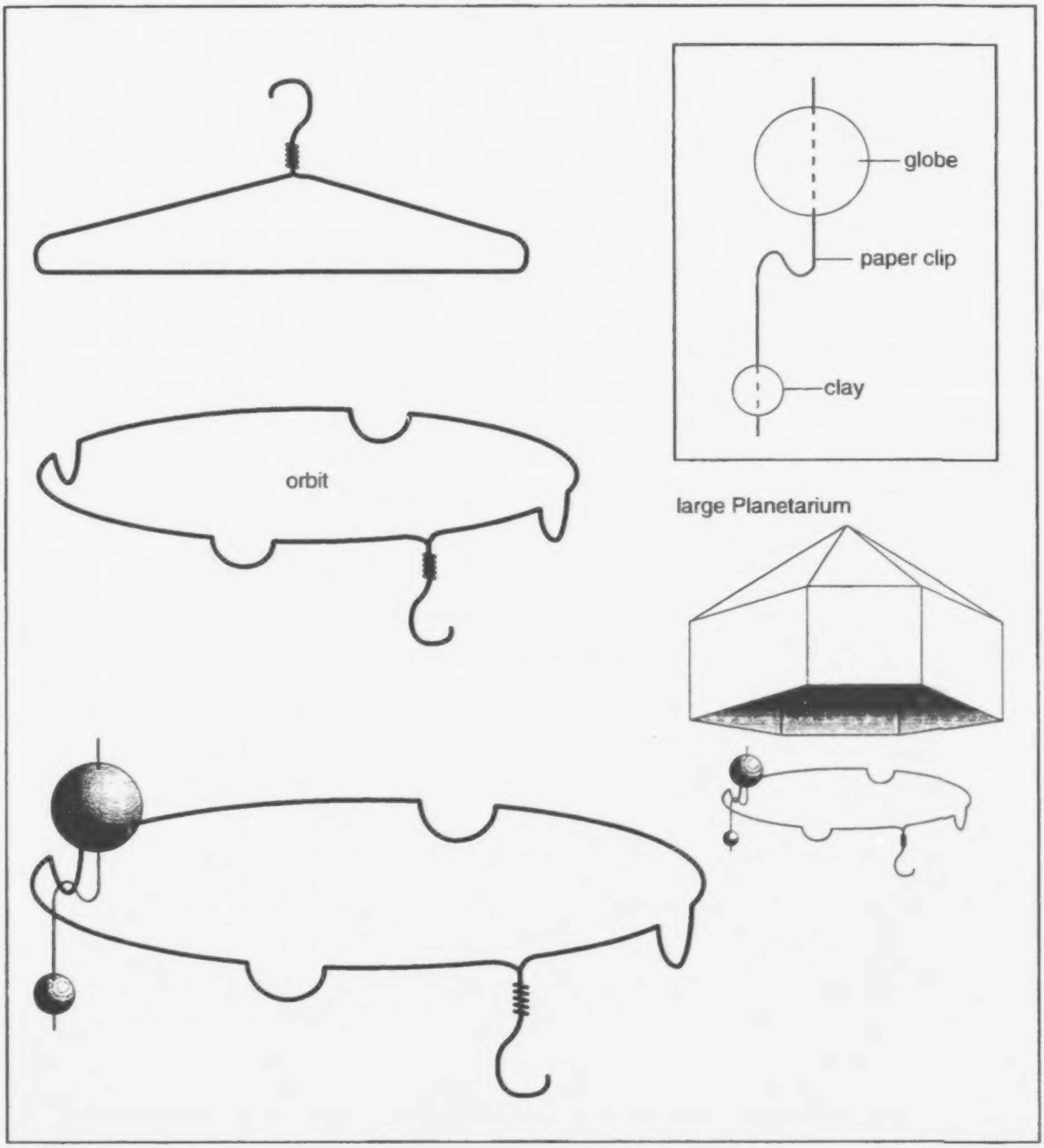

globe
paper clip
clay
orbit
large Planetarium

Figure SP 5.7.5(4) Construction of a coat-hanger orbital model to fit in large Planetarium

Name ______________________________

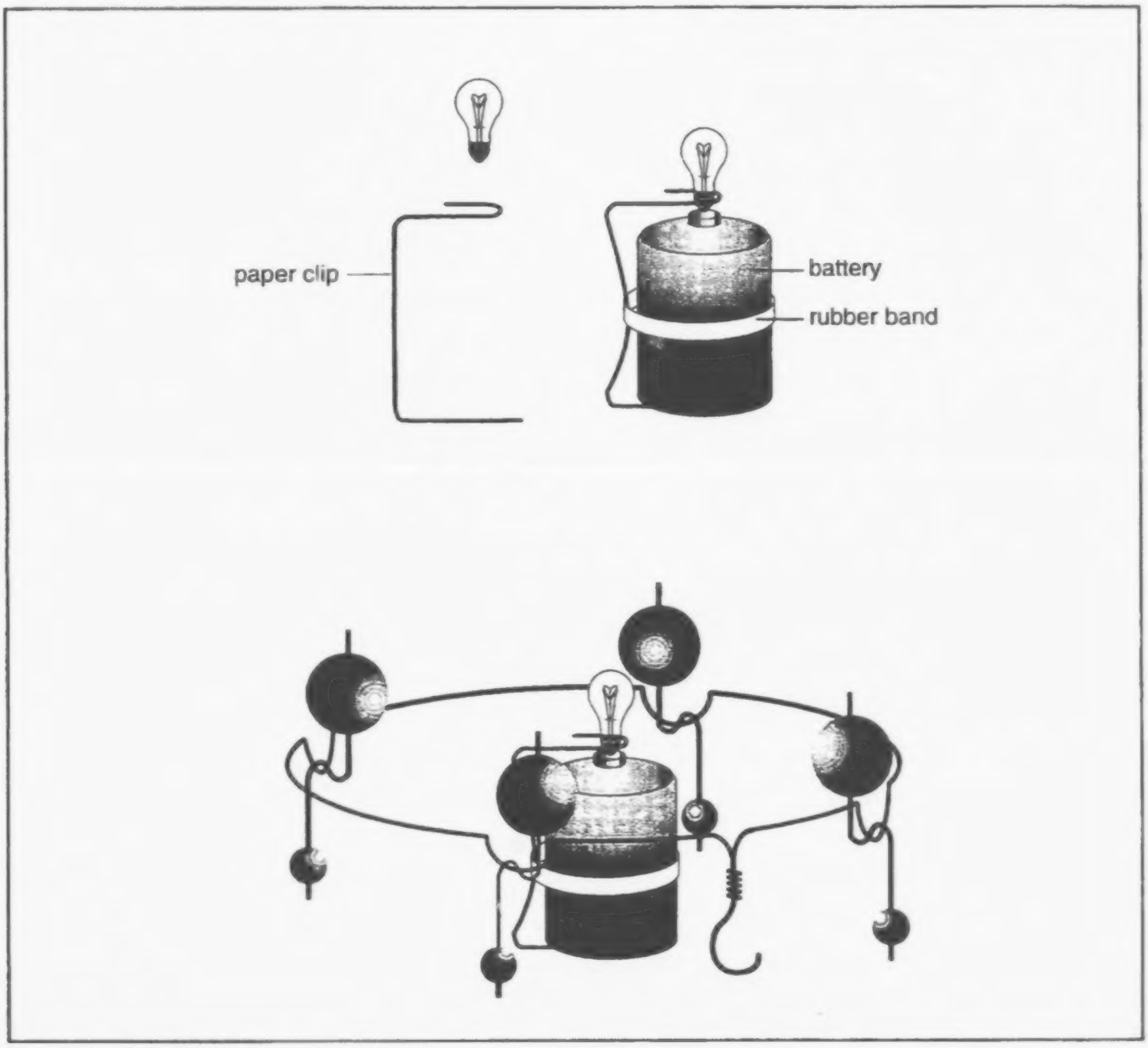

paper clip
battery
rubber band

Figure SP 5.7.5(5) Construction of a battery-and-bulb sun to fit on orbital model to show Earth's seasonal lighting

DASH

GRADE FIVE
CLUSTER 8

Energy and Communication

5.8.1 Pushes, Pulls, and Forces
5.8.2 Teeter-Totters
5.8.3 The Balance
5.8.4 Wheel-and-Axles
5.8.5 Levers: Where Are They?
5.8.6 Arms and Jaws
5.8.7 Inclined Planes and Screws
5.8.8 Block-and-Tackle
5.8.9 Forces Projects

ACTIVITY 5.8.1 PUSHES, PULLS, AND FORCES

OBJECTIVES

The students
- Review their understanding of forces by making a concept map about them.
- Refine their working definition of force.
- Identify different kinds of forces.
- Make force-measuring instruments.
- Predict, test, and explain what happens when different forces oppose each other.
- Make generalizations about movement and non-movement when forces oppose each other.

BACKGROUND

This activity introduces a series of activities on simple machines. It should be preceded by Activities 5.10.1 LINEAR MEASUREMENT and 5.10.2 VOLUME MEASUREMENT. In PUSHES, PULLS, AND FORCES the students refine their working definition of force. They then identify the pushes and pulls in selected situations and make force-measuring tools to test several examples of interacting forces.

Making a Force-Measuring Instrument

A relatively simple force-measuring instrument can be made from rubber bands, ridged wooden or plastic rulers with a hole in the end, string, paper clips, and plastic cups. The amount of stretch of a narrow 2–3 inch rubber band held by a paper clip hooked in the hole at the end of a ruler gives a measure of force. A string 10 to 12 inches long with paper-clip hooks at either end can be used to connect the rubber band to objects that are to pull or be pulled. Before rubber bands are attached, they should be stretched 8–10 times to loosen them up.

Standardizing a Force-Measuring Instrument

To standardize the instrument, have the students hook one end of the string to a plastic cup. See Figure SP 5.8.1. Have them determine the point on the ruler to which the rubber band is stretched by the gravitational pull of 20 mL of water. This should be marked as 20 units of force or simply 20 units. The stretch produced by 40 mL of water should be marked as 40 units of force or 40 units.

Working in Groups

Because two instruments are needed, it is suggested that the students work in groups of four. The same graduate should be used to measure the volume of water for all the instruments made by the group. This will ensure that the instruments are calibrated with the same standard.

Generalizations

By connecting the rulers so they are pulling on each other with different amounts of force, two generalizations emerge:

- There is no movement when opposing forces are equal.
- There is movement in the direction of the stronger force when the opposing forces are unequal.

STUDENT ROLE

Physicist

MATERIALS

ridged wooden or plastic rulers, 12–in (30 cm)
rubber bands, 2–3 in (5–8 cm)
string
scissors
paper clips
plastic, paper, or Styrofoam cups
graduate cylinder from Activity 5.10.2 VOLUMETRIC MEASUREMENT
tape
Student Page 5.8.1 PUSHES, PULLS, AND FORCES

PRODUCTS

force-measuring instruments
Completed Student Pages

PROCEDURES

1. **Help the students develop a concept map reflecting their current understanding of the term *force*.**

   Help them include such things as
   - *Pushes and pulls.*
   - *Weight.* (This is the measure of gravitational force.)
   - *Gravitational* force such as the pull on a falling rock.

- *Magnetic force,* for example, the pull on a compass needle.
- *Electrostatic force,* for example, the attraction or pull of lint to clothing.
- *Elastic force,* for example, the pull of a rubber band when it is stretched.
- *Explosive force,* for example, the push on a bullet by exploding gunpowder.
- *Frictional force*, for example, the resistance of a box being pulled over gravel.

2. **Review the definition of a force as a push or a pull. Use working definitions from DASH 4 if they are available. Help the students record their own working definitions on Student Page 5.8.1 PUSHES, PULLS, AND FORCES.**

3. **Help the students describe the forces in the form of pushes and/or pulls in the following situations and suggest why there is or is not movement.**

Help them

- Describe the forces on a book lying on a desk. (Work to the idea that there are two equal forces. One is the force or weight of the book pushing against the desk and the other is the force of the desk that is pushing back on the book.)
- Describe other examples of opposite forces pushing on each other. (Get at such things as a person leaning against a wall, a car sitting in a driveway.)
- Describe the forces when two teams in a tug-of-war can't move each other. (Work to the idea that these are the two forces pulling in opposite directions.)
- Describe other examples of two forces pulling on each other without movement. (Get at such things as the two ends of a strung bow pulling on each other through the bow string, a picture on a wall pulling on a nail and the nail pulling back.)
- Describe the forces when a person pulls a desk across the floor. (Work to the idea that there are two forces—the pulling on the desk and the frictional force that is resisting the movement.)
- Suggest why in the case of the desk there is movement and no movement in the tug-of-war. (Accept all answers, probing long enough to include the idea that the pulling force on the desk is greater than the resisting force.)

- Suggest how we can tell which force is stronger. (Again accept all answers, probing long enough to include the idea that the direction of movement is in the direction of the stronger force.)
- Demonstrate such a system of unequal forces using their arms and hands. (Work to such things as two opposing hands pulling on each other and not moving, then one relaxing. Movement will be in the direction of the active hand.)

4. **Have the students work in small groups to make force-measuring instruments. Two instruments will be needed. See Figure SP 5.8.1(1).**

5. **Have the students standardize their instruments.**

   Have them standardize the instruments by
   - Marking the end of the rubber band when the cup is empty as 0.
   - Marking the end of the rubber band when 20 mL of water are put in the cup as 20 units of force or just 20 units.
   - Marking the end of the rubber band when 40 mL of water are put in the cup as 40 units of force or just 40 units.

6. **Summarize the making and standardizing of the instrument.**

   Ask such questions as these:
   - What are the forces working when we standardize our force-measuring instrument? (Work to agreement that the force of gravity is pulling on the water and cup and that the elastic force of the rubber band is resisting the pull of gravity.)
   - How could we use our instrument to measure a pull that is equal to the force of gravity on 40 mL of water but is pulling straight up rather than down? (Work to the prediction that the rubber band would probably be pulled the same amount upward as it was downward. See Figure 5.8.1.)
   - How could we test this prediction?

7. **Have the students invent a test of their prediction and demonstrate their methods of testing.**

Ask such questions as these:

- How did you test the prediction? (Have them demonstrate their tests. Be sure some group connects the instruments one above the other and that they pull down on the bottom instrument so that they measure the stretch on both instruments. The rubber bands should stretch to the 40-unit point on both instruments, thus giving equal but opposite forces. See Figure 5.8.1.)
- Does the two-instrument system show that we can use the same instrument to measure forces straight up and straight down? (Work to agreement that the instruments can be used to measure forces either up or down because the same force is registered on both instruments.)
- How about horizontally or sideways? (Work to agreement that the two-instrument system can be used sideways because the same force is again registered on both instruments.)

8. **Have the students connect the instruments when they are laid flat on the table as shown in Figure SP 5.8.1.**

Have the students

- Hold the hooks connecting the strings so that the strings cannot move.
- Stretch the two instruments to each read 20 units of force, then hold the ruler so the frame cannot move but the rubber band can.
- Predict what will occur when the hooks are released.
- Test the system.
- Report what they observe and explain the results. (The rubber bands on the two instruments will move little if at all. Two equal forces in opposite directions balance each other and produce no movement.)

9. **Have the students use the same setup as above, holding the hooks and stretching the two instruments to read 40 units of force. See Figure SP 5.8.1.**

Have them

- Predict what will happen when the hooks are released.
- Test the system.
- Have the students report what they observe and explain the results. (As before, the rubber bands on the two instruments will move little if at all. Two equal forces in opposite directions counterbalance each other and produce no movement.)

10. **Have the students use the same setup as above, holding the hooks and stretching one instrument to read 40 units of force and the other to read 20 units of force. See Figure SP 5.8.1.**

    Have them
    - Predict what will happen when the hooks are released.
    - Test the system.
    - Have the students report what they observe and explain the results. (The rubber bands on both instruments will move. The movement will be in the direction of the 40 units of force. Two unequal forces pulling in opposite directions results in movement in the direction of the stronger force.)

11. **Have the students invent their own experiment using their force instruments, making predictions, and explaining them. (They might make different force measurements, be quantitative in their prediction as to the amount of movement, put three of more instruments in a chain, and so forth.)**

12. **Summarize the investigations with the students.**

    Ask such questions as these:
    - What is force?
    - What happens when equal forces oppose each other? (The things producing the forces do not move.)
    - What happens when unequal forces oppose each other? (There is movement in the direction of the stronger force.)

EXTENSION

- Have the students write a story about how many small forces countered a great force. Get at the idea that the sum of the small forces must exceed the great force.

ILLUSTRATION

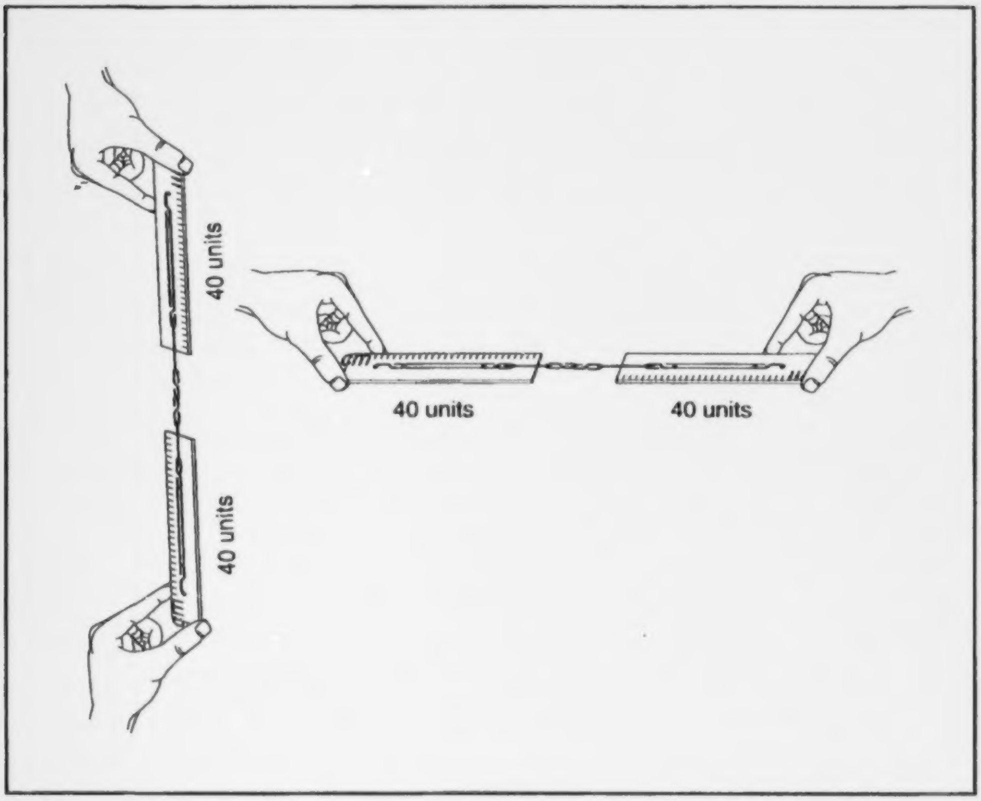

40 units
40 units
40 units
40 units

Figure 5.8.1 Measuring the force pulling down against an upward force of 40 units. The measured force pulling down is equal to the opposing upward force. Also showing that opposing horizontal forces are equal.

DASH

Name________________________

Date________________________

STUDENT PAGE 5.8.1 PUSHES, PULLS, AND FORCES

1. Record your working definition of a force.

2. Give examples of each of the following:
   - A *pull* operating against a *pull* without movement.
   - A *push* operating against a *push* without movement.
   - A pull operating against a *pull* with movement.
   - A push operating against a *push* with movement.

3. Make two force-measuring instruments. See Figure 5.8.1. Describe how you standardized your instruments to measure the force produced by 20 and 40 mL water. Call these measurements 20 and 40 *units of force* or just *units.*

Name ______________________________

4. Describe how you used your instruments to measure 40 units of force pulling straight down, up, and sideways. Use drawings as needed.

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5. Connect the instruments as shown in Figure SP 5.8.1. Use your finger to hold the paper-clip hooks attached to the string so they do not move when the rubber bands are stretched. Record your predictions about the hooks' movement when they are released. Test and record what actually happens.

Two rubber bands are stretched so that 20 units of force oppose 20 units of force.

PREDICTED MOVEMENT ______________________________

ACTUAL MOVEMENT ______________________________

Two rubber bands are stretched so that 40 units of force oppose 40 units of force.

PREDICTED MOVEMENT ______________________________

ACTUAL MOVEMENT ______________________________

Two rubber bands are stretched so that 40 units of force oppose 20 units of force.

PREDICTED MOVEMENT ______________________________

ACTUAL MOVEMENT ______________________________

Name ______________________________

6. **Describe what opposing forces are like when movement takes place and when it doesn't.**

7. **Describe your own investigations with force-measuring instruments.**

ILLUSTRATION

Name ______________________________

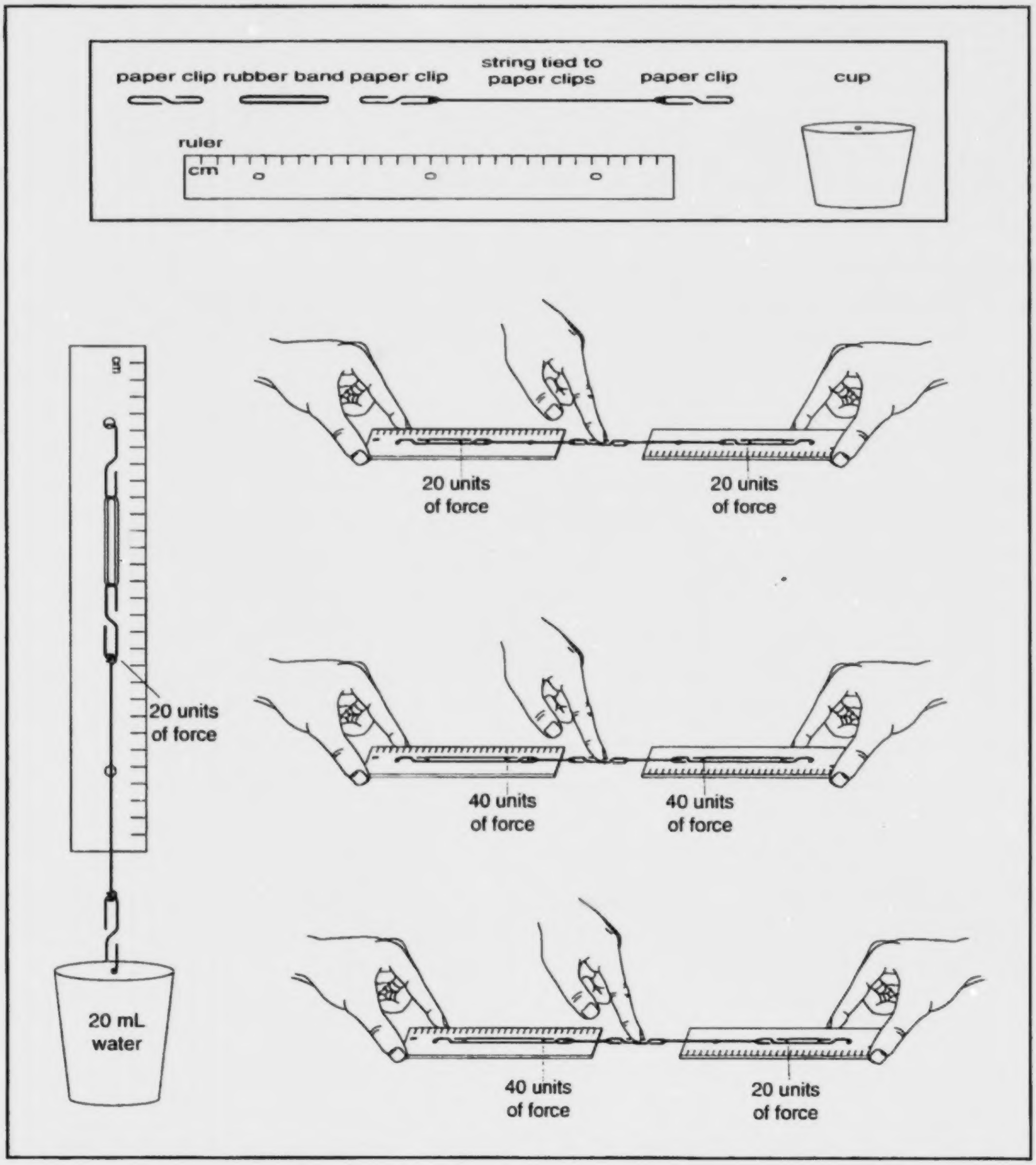
paper clip
rubber band
paper clip
string tied to paper clips
paper clip
cup
ruler
cm
cm
20 units of force
20 mL water
20 units of force
20 units of force
40 units of force
40 units of force
40 units of force
20 units of force

Figure SP 5.8.1 Parts for a force-measuring instrument, assembly and standardization of the instrument, and arrangement of two instruments for investigating interacting forces. Force is measured as the amount of stretch of the rubber band.

ACTIVITY 5.8.2 TEETER-TOTTERS

OBJECTIVES

The students

- Begin their study of levers by using a teeter-totter as a model.
- Generalize that paper clips of the same size balance each other on a teeter-totter when they are placed equal distances from the fulcrum.
- Generalize that when different numbers of paper clips of the same size are placed on a teeter-totter, they can be balanced by moving the larger number closer to the fulcrum.

BACKGROUND

This is the second activity in the series on simple machines. Here the students are introduced to the lever. Because most students have had considerable experience with teeter-totters, DASH uses the teeter-totter as a model of a lever. This activity should be preceded by Activity 5.8.1 PUSHES, PULLS, AND FORCES. It should be followed by Activity 5.8.3 THE BALANCE where the students apply the generalizations developed in TEETER-TOTTERS as they make balances.

Levers

Levers are machines consisting of a rigid bar or beam that turns or swings about a *pivot* or *fulcrum*. Levers allow us to use a small amount of force to produce a great deal of force. A short swing of one end of a lever can produce a longer swing at the other end. For example, a small child sitting far from the fulcrum of a teeter-totter can counterbalance an adult sitting close to the fulcrum on the other side. When the teeter-totter swings up and down, the child swings farther than the adult.

The Teeter–Totter

A standard 12-in (30-cm) ruler can be made into a teeter-totter by using a rubber band to secure a paper clip or piece of wooden skewer at its middle to act as a fulcrum. See Figure 5.8.2. This teeter-totter can be supported between two desks, two books, or any two surfaces the students select.

Stabilizing the Teeter-Totter.

To give stability to the teeter-totter, bend a paper-clip fulcrum so that the ruler is slightly below the point where the clip contacts the support. See Figure 5.8.2. If a piece of skewer is used, the teeter-totter will be most stable when it is attached to the top of the ruler. Both techniques lower the teeter-totter's center of gravity. Be sure the piece of skewer has no flat surfaces.

Generalization

The students first develop a *descriptive* generalization about how to move paper clips on their ruler to achieve balance. Then they experiment further to find a *quantitative* generalization that allows them to predict where paper clips must be placed on the teeter-totter to achieve balance.

Descriptive Generalizations

The students' descriptive generalizations will rely on language to describe how the lever operates. When generalizing they move from using specific language to general language. For example, a student might say that

- equal numbers of paper clips of the same size placed on either side of a teeter-totter are made to balance by moving them equal distances from the fulcrum

Quantitative Generalizations

A *quantitative* generalization about paper clips of equal size on a teeter-totter will include the number of paper clips and measured distances from the fulcrum. For example a student might say that

- paper clips of equal size on opposite sides of a teeter-totter will balance when the products of their distance from the fulcrum and their numbers are equal

Giving Challenges

When students ask you to test their understanding of how to establish balance, tell them where to place the smaller number of paper clips. Have them find where to put the larger number. This will ensure that both the larger and smaller number of paper clips will always be on the teeter-totter.

Record Keeping

In arriving at a quantitative generalization it is important to keep data. A data table is included in the Student Page. It is suggested, however, that this table be given out only *after* the students have had a chance to explore the system and find the variables in the problem—distances from the fulcrum and the number of paper clips.

Flexibility of Procedures

The procedures outlined are only suggestions. Each class will work at the problems differently, and the procedures should be modified accordingly. When students ask questions or are stuck, use a Socratic questioning approach to reveal patterns. This activity may take several sessions to complete.

When to Go On

If after Procedure 10 no students have seen a pattern in the data leading to a quantitative generalization, proceed to Activity 5.8.3 THE BALANCE and work further at the engineering of a balance. To extend the ideas developed here, it will be helpful to set up an activity center as described in the Extension. Teeter-totters will be returned to many times in the mechanics sequence in different contexts. When the students see a quantitative pattern, have them come back to Procedure 11 and help others.

STUDENT ROLE

Physicist

MATERIALS

wood skewers cut into 7–8 cm pieces
12-in (30-cm) wood or plastic ruler
15–20 large paper clips per teeter-totter
2 small paper clips per teeter-totter
rubber bands
Student Page 5.8.2 TEETER-TOTTERS

PRODUCTS

Completed Student Pages

PROCEDURES

1. **Have the students make a teeter-totter. Help them use a paper clip or short piece of a wood skewer for a fulcrum, a rubber band to secure the fulcrum, and a ruler for the teeter-totter. See Figure 5.8.2. Help them invent their own support system for the teeter-totter and a way to get their teeter-totter to balance.**

Ask such questions as
- What is a *fulcrum?* (If the students do not know, help them look up the term fulcrum and add it to the Working Dictionary. Work to the idea of a supporting pivot around which a lever or teeter-totter turns.)
- How did you get your teeter-totter to balance? (Have the students demonstrate what they did in moving the fulcrum back and forth. If some students are not successful in getting their teeter-totter to balance, have other students help them.)

2. **Pose Problem A:** ***Two paper clips are the same size. If one is put any place on one side of the teeter-totter, where would you put the other paper clip to keep the teeter-totter balanced?***

   Help the students
   - Explore the problem.
   - Demonstrate how they got the teeter-totter to balance.
   - Discuss and generalize their findings. (Work toward the idea that the paper clips will be approximately equal distances from the fulcrum on opposite sides.)
   - Demonstrate how the paper clip can be made to run at right angles to the edge of the teeter-totter. This standardizes the operations. See Figure 5.8.2.)

3. **Pose Problem B:** ***Two paper clips have quite different sizes. The small paper clip is put near the end of a teeter-totter. Can you balance the teeter-totter with a larger paper clip? If so, where would you have to put the larger paper clip to keep the teeter-totter balanced?***

   Have the students
   - Demonstrate how they got the teeter-totter to balance.
   - Discuss and describe their findings. (Work toward a descriptive statement that the paper clips will be on opposite sides of the teeter-totter and that the heavy paper clip will be closer to the fulcrum than the small paper clip.)

4. **Help the students expand their investigation by putting two paper clips of the same size on opposite sides of the teeter-totter. Ask them to balance the teeter-totter and describe how they did it.**

Help the students
- Share their results.
- Describe how they balanced the teeter-totter. (Work for something like this: When paper clips are the same size, to get balance equal numbers are placed equal distances from the fulcrum on opposite sides of the teeter-totter.)
- Try to explain exceptions.

5. **Pose Problem C: *If one paper clip is 8 cm from the fulcrum, where would you have to place 2 paper clips of the same size hooked together to balance the teeter-totter?* See Figure 5.8.2.**

Help the students
- Explore the problem.
- Demonstrate how they got their teeter-totter to balance.
- Discuss their findings. (Work toward the idea that the 2 paper clips hooked together will need to be just about 4 cm from the fulcrum on the opposite side from the single paper clip 8 cm from the fulcrum. Keep track of all demonstrated exceptions.)

6. **Pose Problem D: *If one paper clip is 6 cm from the fulcrum, where would you place 2 paper clips of the same size hooked together to balance the teeter-totter?***

Help the students
- Explore the problem.
- Demonstrate how they got the teeter-totter to balance.
- Discuss their findings. (Work toward the idea that the 2 paper clips hooked together will need to be about 3 cm from the fulcrum on the side opposite the single paper clip at 6 cm. Keep track of all demonstrated exceptions.)

7. **Introduce the data table on Student Page 5.8.2 TEETER-TOTTERS and pose Problem E: *Can you find a way to predict where you would place 2 paper clips to balance a single paper clip when the single paper clip is placed anywhere along one side of the teeter-totter?***

Have the students
- Explore the problem.
- Inspect their data for patterns that will allow them to make predictions.

- Ask you to place 1 clip at some arbitrary distance once they think they can make predictions.
- Predict where the 2 paper clips will need to be placed to achieve balance and test their prediction.
- Demonstrate how they got the teeter-totter to balance.
- Discuss and generalize their findings. (Work toward a quantitative generalization such as the single paper clip will need to be is twice as far from the fulcrum as the 2 paper clips. Keep track of all demonstrated exceptions.)

8. **Pose Problem F:** ***Can you find a way to predict where you would need to place 4 paper clips to balance 1 paper clip when it is placed anywhere along one side of the teeter-totter?***

   Have the students
   - Explore the problem.
   - Inspect their data for patterns that will allow them to make predictions.
   - Ask you to place 1 clip at some arbitrary distance once they think they can make predictions.
   - Predict where the 4 paper clips will need to be placed to achieve balance and test their prediction.
   - Demonstrate how they got the teeter-totter to balance.
   - Discuss and generalize their findings. (Work toward a quantitative generalization, such as the single paper clip will need to be 4 times as far from the fulcrum as the 4 paper clips. Keep track of all demonstrated exceptions.)

9. **Pose Problem G:** ***Can you find a way to predict where you would need to place 4 paper clips to balance 2 paper clips when the 2 paper clips are placed anywhere along one side of the teeter-totter?***

   Have the students
   - Explore the problem.
   - Inspect their data for patterns that will allow them to make predictions.
   - Ask you to place 2 clips at some arbitrary distance once they think they can make predictions.
   - Predict where the 4 paper clips will need to be placed to achieve balance and test their prediction.
   - Demonstrate how they got their teeter-totter to balance.

- Discuss and generalize their findings. (Work toward quantitative generalizations. Examples might be
  - that the 4 paper clips are half as far from the fulcrum as the 2 paper clips
  - that the 4 paper clips times the distance from the fulcrum is equal to 2 paper clips times their distance fulcrum, and so forth)

10. **If the students need additional work on generalization, give them another pair of paper-clip numbers, for example, 2 with 5 or 3 with 5. Again seek a generalization.**

11. **When the students have a quantitative generalization to cover multiple paper clips, pose Problem H: *Can you predict where you would place any number of paper clips to balance a known number of paper clips placed a known distance from the fulcrum?***

    Have the students
    - Explore the problem.
    - Inspect their data for patterns that will allow them to make universal predictions.
    - Ask you to place some number of clips at some arbitrary distance from the fulcrum.
    - Demonstrate how they got the teeter-totter to balance.
    - Discuss and generalize their findings. (Work toward the *quantitative* generalization that the number of paper clips times the distance from the fulcrum on one side is equal to the number of paper clips times their distance from the fulcrum on the other side.)

EXTENSION

- Set up a balancing center with a teeter-totter 1 meter long. Provide paper clips other objects of known mass. Challenge the students to test the balancing rules on the larger system. Set up a master record sheet and periodically review the recorded findings.

ILLUSTRATION

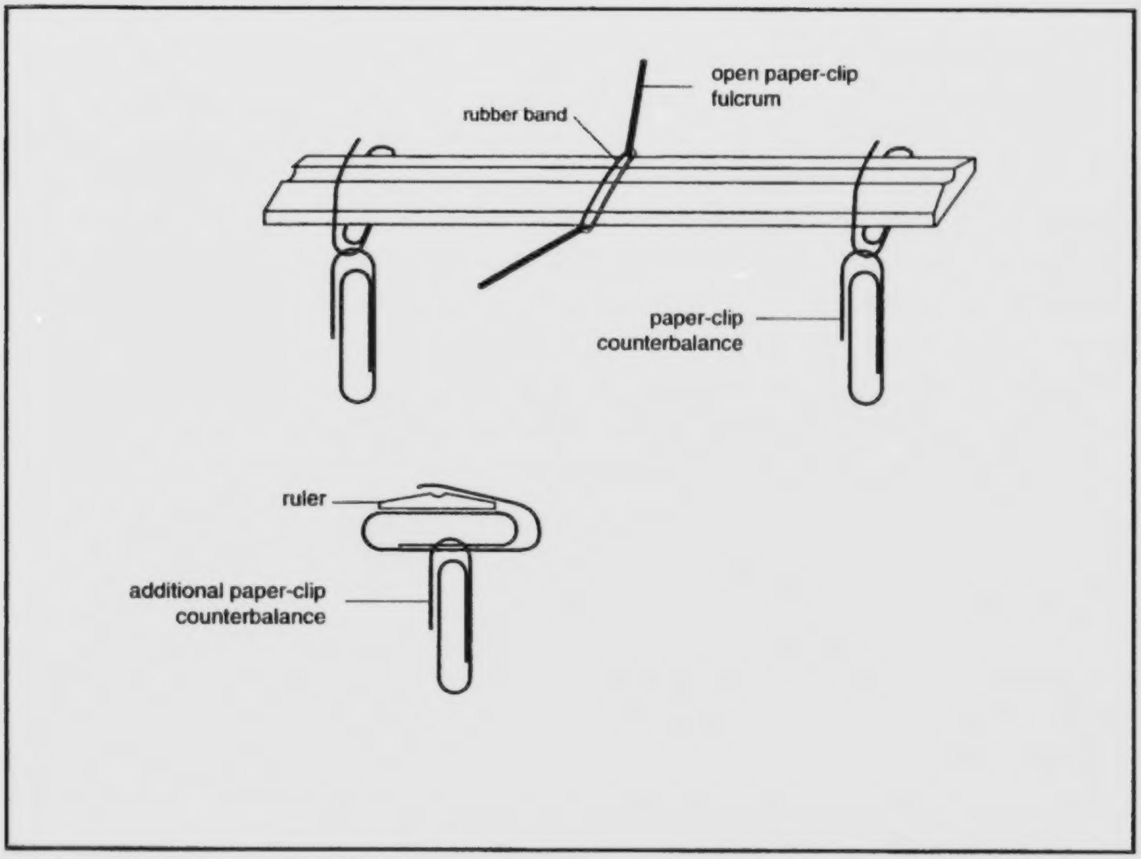
open paper-clip
fulcrum
rubber band
paper-clip
counterbalance
ruler
additional paper-clip
counterbalance

Figure 5.8.2 A ruler teeter-totter

1070

Name________________________

Date________________________

STUDENT PAGE 5.8.2 TEETER-TOTTERS

1. Draw your teeter-totter and explain how it works.

Name ______________________________

2. Use the table below to record your data.

Table SP 5.8.2 Teeter-totter data

Number of paper clips on left side	Distance from fulcrum on left side	Number of paper clips on right side	Distance from fulcrum on right side

3. Describe how a child and a parent can adjust their positions on a teeter-totter to keep balance.

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Name ______________________________

4. **Make a quantitative generalization about teeter-totters. Describe how paper clips and distances can be adjusted to keep balance.**

ACTIVITY 5.8.3 THE BALANCE

OBJECTIVES

The students
- Make a metric balance.
- Make metric counterbalances.
- Apply their understanding of levers in making adjustable counterbalances.
- Use the Pythagorean method for getting equal divisions or techniques of their own to calibrate a balance.

BACKGROUND

Each year DASH students craft their own metric measuring tools. In DASH 5 the students apply their understanding of levers. THE BALANCE should follow Activities 5.10.1 LINEAR MEASUREMENT, 5.10.2 VOLUME MEASUREMENT, 5.8.1 PUSHES, PULLS, AND FORCES, and 5.8.2 TEETER-TOTTERS. In THE BALANCE the students start by continuing their reading on mass and the metric system. See Student Page 5.8.3A METRIC MASS MEASUREMENT.

Prototype Balance

Before beginning the activity you will need to have students build a prototype balance or build one yourself. The design suggested here is simple and quickly put together. See Figure 5.8.3.
- **Base**—Use the corner of a heavy cardboard box with a height of 10–12 inches (25–30 cm). Because the balance will often be used to measure the mass of water, it is advisable to tape the corrugated edges and paint the entire base.
- **Fulcrum**—Use coat-hanger or other stiff wire to act as the fulcrum. For greater sensitivity the balance beam can be suspended from a jumbo paper-clip fulcrum attached to the wire holder.
- **Balance beam**—Use a rigid wooden or plastic ruler that has three holes—one in the center and two equal distances from the center near the end.
- **Beam stabilizer**—Use two clothespins attached to the ends of the beam to stabilize it. Before using the balance, adjust the clothespins to bring the beam into balance. Once measurement is started, don't move the clothespins.
- **Pans**—Use soft plastic drinking cups.
- **Pan hangers**—Use heavy jumbo clips.

Water As a Counterbalance

Use a student-made graduated cylinder to measure water. Each milliliter or cubic centimeter of water has a mass of 1 g. Use the same standard graduate to measure out 80 g of water for each group making a balance.

Clay Counterbalances

Have the students make a series of counterbalances. To do this have them pour 80 g of water into one plastic cup and put enough modeling clay to counterbalance the water in the other cup. Have them divide the 80 g of clay in half by putting 40 g in each cup. They should cover the 40 g to be used as a counterbalance with very thin plastic, removing just enough clay to keep it in balance with the 40 g of uncovered clay in the other cup.

Have the students follow the same procedure to divide the 40 g of remaining clay in half to make a 20-g counterbalance. They can then divide the leftover 20 g of clay into two 10-g counterbalances. The counterbalances should be covered with plastic to keep them from losing clay or getting dirty.

To make an adjustable counterbalance, have the students insert a paper clip into one of their 10-g counterbalances so that it can hang from the beam. They should remove just enough clay to compensate for the mass of the paper clip.

Calibrating the Beam

The beam of the balance can be calibrated in the following way:

- Cover the upper edge of the balance beam with masking tape.
- Use the Pythagorean technique to divide the tape into 10 divisions. Start at the fulcrum (0 point) and go to the point where the cup is suspended, the 10-g point. Ten equally spaced marks will allow mass readings in 1-g increments using the adjustable counterbalance.
- Divide the 1-g intervals on the tape into 1-decigram (dg) or 1/10-g intervals. This can be done by copying a 1-g interval on a 3 x 5-in index card and dividing it into 10 equal divisions. The card can be used to determine the fractional part of a gram.

Help the students invent a way to keep their adjustable counterbalance from slipping. One way is to place a tiny piece of masking tape around the hook to give a sticky surface.

STUDENT ROLE

Engineer

MATERIALS

3-hole plastic or wooden ruler
plastic wrap
heavy-duty cardboard box at least 30 cm x 30 cm x 30 cm
coat-hanger or other stiff wire
jumbo paper clips
masking tape
waterproofing paint for cardboard base
9- or 12-oz soft plastic cups for weighing pans
3 x 5-in index cards
modeling clay
newspaper
bricks or other mass to secure the balance
clothespins to stabilize the balance beam
Student Pages 5.8.3A METRIC MASS MEASUREMENT
5.8.3B THE BALANCE

PRODUCTS

Balances
Completed Student Pages

PROCEDURES

1. **Have the students read Student Page 5.8.3A METRIC MASS MEASUREMENT.**

   Ask such questions as
   - What is mass? (Get at the idea that mass is a measure of the amount of matter or stuff in anything that we can see, feel, or otherwise sense.)
   - How was the prototype gram first defined? (The gram was defined as the mass in one cubic centimeter of water at 4°C.)
   - How does the cubic centimeter compare with the milliliter? (They are the same.)

2. **Introduce the need for balances that can measure the mass of objects to a gram or less. Discuss the structure of such a balance. Demonstrate a prototype. See Background.**

Ask such questions as

- How is the balance similar to the one you have used before? (It has a fulcrum in the center, a beam, and weighing pans suspended at either end.)
- How could we secure the balance so that it will not fall over? (Entertain such ideas as weighting it down, clamping it, and so forth.)
- How could we be sure when we have reached balance? (Get at the idea that we could add a pointer or other device that will tell us when the beam is at the balance point.)

3. **Help groups of students make versions of the prototype and demonstrate that they are in balance.**

Help them

- Demonstrate how their balance operates by placing an object in one cup and counterbalancing it with clay in the other cup.
- Exchange cups to check that the two arms of the beam are balanced.

4. **Discuss how to make a set of counterbalances.**

Ask such questions as

- What is the relationship between a gram and a cubic centimeter of water? (Reinforce the idea that from near the freezing temperature of water to well above room temperature a cubic centimeter or milliliter of water has a mass close to 1 g.)
- What could we use as a known counterbalance to measure the mass of an object? (Work toward the idea of using a measured volume of water.)
- How could we make a set of permanent counterbalances? (Help the students recall the clay counterbalances that they made in DASH 4.)

5. **Help groups of students invent and make one 40-g, one 20-g, and two 10-g counterbalances, starting with 80 g of clay. Show them a prototype with plastic covering. Help them check their masses by comparing them with other groups'. See Background.**

6. **Help the students insert a paper clip into a 10-g mass to act as an adjustable counterbalance. Have them work out a way to calibrate the balance beam to give 1-g readings.**

Help them

- Put tape on the upper edge of the balance beam.
- Divide the distance from the 0 point at the fulcrum to the 10-g point over the weighing pan into 10 equally spaced intervals. (If needed, review the Pythagorean technique. See Activity 5.10.1 LINEAR MEASUREMENT.)
- Invent a way to keep the 10-g counterbalance from slipping.
- Invent a way to use the 10-g adjustable counterbalance to measure masses of less than 10 g.
- Invent a way to subdivide a 1-g interval into decigrams (1/10 g).

7. Summarize the activity.

Ask such questions as

- How does the work you did with teeter-totters apply to the use of two pans (cups) on the balance beam? (Work for agreement that because the pans are equal distances from the fulcrum, the force pushing down on both pans must be the same.)
- Why do we use the clothespins to get the beam in balance before we start? (Work for agreement that the balance can easily get out of adjustment when we are not using it.)

EXTENSION

- Have the students list ways that teeter-totters and balances are alike and different.

ILLUSTRATION

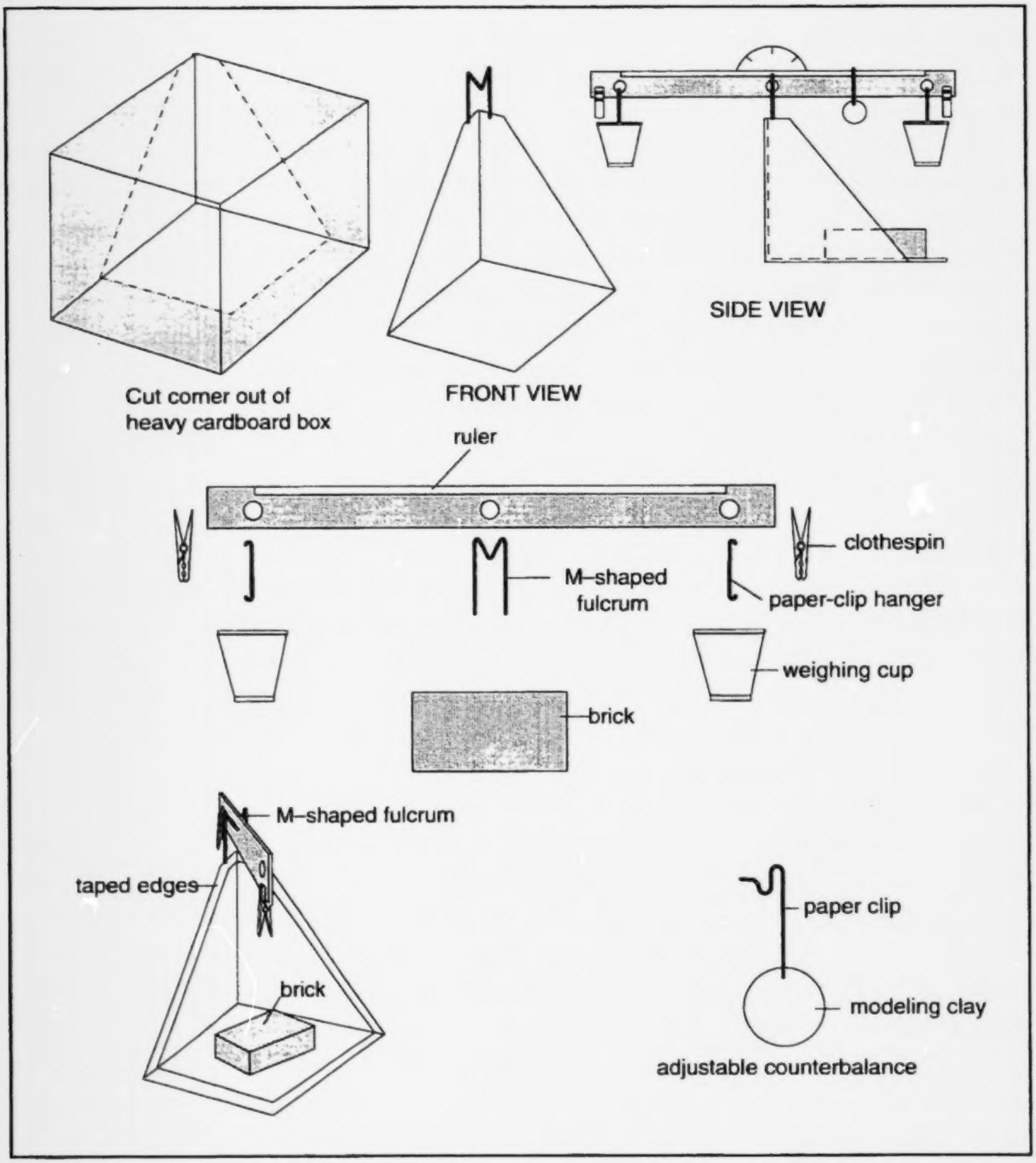
Cut corner out of heavy cardboard box
FRONT VIEW
SIDE VIEW
ruler
clothespin
M–shaped fulcrum
paper-clip hanger
weighing cup
brick
M–shaped fulcrum
taped edges
brick
paper clip
modeling clay
adjustable counterbalance

Figure 5.8.3 Prototype balance

DASH

Name______________________________

Date______________________________

STUDENT PAGE 5.8.3A METRIC MASS MEASUREMENT

THE METRIC SYSTEM AND MASS MEASUREMENT

Mass

The *mass* of a thing is a measure of the amount of matter in it. *Matter* is anything that we can feel. Matter includes all solids, liquids, and gases. We measure mass on a balance. Common units of mass in the metric system are the *gram* and the *kilogram*. One kilogram is 1,000 grams.

History of Mass Units

The French creators of the metric system built the metric mass units around metric volume. A gram was defined as the mass of 1 cubic centimeter of water, measured at 4°C. Fortunately, the mass of 1 cubic centimeter or milliliter of liquid water remains about 1 gram from 0°C to well above room temperature.

The U.S. System of Measurement

The U.S. pound (lb) was standardized with the kilogram in 1893. There are 16 ounces (oz) in a pound, and 454 grams (g) of matter have the same weight as a pound.

METRIC AND U.S. UNITS OF MASS

1 kilogram (kg) = 2.20 pounds (lb)
1 pound (lb) = 0.45 kilograms (kg)
1 pound (lb) = 454.00 grams (g)
1 ounce (oz) = 28.40 grams (g)

Name________________________

Date________________________

STUDENT PAGE 5.8.3B THE BALANCE

1. Define mass.

2. Draw your balance and explain how it works.

ACTIVITY 5.8.4 WHEEL-AND-AXLES

OBJECTIVES

The students
- Find similarities between wheel-and-axle systems and teeter-totter systems.
- Make wheel-and-axle systems with multiple wheels.
- Determine what counterbalances attached to wheels of different sizes keep the system from turning.
- Determine under what conditions counterbalances attached to wheels cause the system to turn.
- Determine the relative amounts of line reeled in and run out when unbalanced counterbalances are attached to wheels of different sizes.

BACKGROUND

WHEEL-AND-AXLES is part of the simple machine series. It should be preceded by Activities 5.8.1 PUSHES, PULLS, AND FORCES, 5.8.2 TEETER-TOTTERS, and 5.8.3 THE BALANCE.

The Approach

In WHEEL-AND-AXLES the students make wheels out of heavy cardboard and glue them together to make wheel-and-axle systems. They then investigate to find that a wheel-and-axle system works the same way a teeter-totter system works: when forces are equal, there is no movement, and when the forces are unequal, there is movement. They verify that when the amount of mass times the distance to the fulcrum on one side is equal to the mass times the distance to the fulcrum on the other side, there is no movement. Student Pages are used to guide in the construction of equipment and visualization of problems.

Circle Cutter

Make circle cutters from 1 x 2-in wood blocks 16–20 in long. Attach a razor blade at the end of each block so that the tip of the blade extends below the block. See Figure 5.8.4(1). Drill 1/8-in centering holes 12, 6, and 4 cm from the razor-blade end. This will allow insertion of a large nail to act as an axle and the cutting of wheels with 24-, 12-, and 8-cm diameters.

Wheels

For this activity each working group will need three wheels with diameters of 24, 12, and 8 cm. Because the cutting of the wheels involves use of a razor blade, you may wish to cut the wheels yourself. Wheels should be made of thick corrugated cardboard.

Commercial cardboard cake plates with diameters of 4, 6, and 12 in (10 cm, 15 cm, 30 cm) can be substituted for cut-out wheels. The proportions are the same as the 8-, 12-, and 24-cm wheels. Have the students invent a way to find the wheels' centers. One technique is to trace and cut out paper circles and then fold the circles in quarters.

Grooving Wheels

A groove to hold string can be made in the rims of the wheels by pressing the side of a large nail (12- to 16-penny) or a chopstick into the corrugations at the rim. NOTE: A pin or a peg can be put into the corrugation of the rim to secure the string.

Assembling Wheel-and-Axles

Glue the three wheels together to make a multiple wheel-and-axle system. The wheels should have a common center. See Figure SP 5.8.4(1). An axle can be made out of a nail or a piece of coat hanger. In balancing the wheel a streak of clay applied on the side of the wheel opposite any heavy spot will act as a counterbalance.

Counterbalances

Use the counterbalances made in Activity 5.8.3 THE BALANCE. Additional counterbalances can be made out of fresh clay and a paper clip. Their mass can be determined on the balance.

Use of Wheels

Activity problems use no more than two wheels at a time, though the students may use all three in their explorations. The three different sizes allow testing of similarities in wheel-and-axle and teeter-totter systems.

STUDENT ROLES

Physicist
Mechanical engineer

MATERIALS

pins or pegs to secure string
12-in (30–cm) ruler
1 x 2-in wood block 16–20 in long for circle cutter
1/8-in drill bit
drill
12- or 16-penny nails
rubber bands
small finishing nails for pegs
single-edged razor blades
heavy corrugated cardboard for wheels
    alternative: 4-, 6-, and 12-in cardboard cake plates
glue
string
modeling clay
coat hangers for axles
pliers
counterbalances from Activity 5.8.3 THE BALANCE
balances from Activity 5.8.3 THE BALANCE
Student Page 5.8.4 WHEELS AND AXLES

PRODUCTS

Wheel-and-axle systems
Completed Student Pages

PROCEDURES

1. **Help the students make wheel-and-axle systems out of corrugated cardboard. Give them precut circles to use as wheels or help them make their own wheels with diameters of 24, 12, and 8 cm. Have the students use Student Page 5.8.4 WHEELS AND AXLES to guide their work.**

   Help the students
   - Make a groove in the rim of each circle by pressing in with the side of a large nail or using other techniques they invent. Have them go completely around the wheel.
   - Center the circles and glue the wheels together. (See Figure SP 5.8.4[1]. Some problems will use only one and some two of the three wheels of the systems at a time.)
   - Invent a way to suspend the wheel system between desks.

- Check to see that the system is free turning and is balanced.
- If necessary, balance the system by adding dabs of modeling clay on the side of the rim opposite any heavy spot. (Associate the balancing of the wheel-and-axle system to balancing car wheels in a tire shop.)

2. **Pose *Problem A: Secure a string on the rim of the 24-cm wheel. Wrap a string around the rim and suspend a 20-g counterbalance from one side. Predict the mass of a counterbalance on the other side that will keep the wheel system from turning.* See Figure 5.8.4(2).**

3. **Help the students test their predictions.**

   Ask such questions as these:
   - What counterbalancing mass did it take to keep the wheel from turning? (Work for agreement that the mass had to be about 20 g on both sides.)
   - What counterbalancing mass would it take to keep a 40-g counterbalance from turning the wheel? (Have the students test their answers. Work for agreement that the mass had to be about 40 g on both sides.)
   - Will the wheel move if two counterbalances of equal mass are put on opposite sides of wheels of other sizes? (Have the students test their answers. Work toward the idea that there will be no movement.)
   - What mass would it take to keep the wheel turning? (Have the students test their answers. Work toward the idea that one side would have more mass.)

4. **Discuss how a wheel-and-axle system might be like a teeter-totter system. Help the students test the possibility.**

   Ask such questions as these:
   - What is an axle? (Help the students look up the term *axle*.)
   - What part of a teeter-totter system would an axle correspond to? (Develop the idea of the fulcrum.)
   - What would the outer edges of wheels correspond to? (The wheel edges would correspond to the ends of the teeter-totter.)
   - What would a teeter-totter system that is similar to your wheel-and-axle system look like? (Help the students draw such a system. See Figure 5.6.4[2].)

- Does the teeter-totter system you have drawn act the same way as your wheel-and-axle system? (Help the students set up a teeter-totter system and test their predictions.)
- What were your results? (Work toward agreement that they get close to the same results.)

5. Pose *Problem B*: ***Secure a string on the rim of the 24-cm wheel. Wrap the string around the rim and suspend a 20-g counterbalance from one side. Secure another string to the rim of the 12-cm wheel and wrap it around the rim. Predict the mass of a counterbalance needed to keep the wheel system from turning. Record your prediction and test the system.*** **See Figure 5.8.4.(3).**

   Help the students
   - Predict whether the counterbalance on the small wheel will have to be larger, smaller, or the same size as the 20-g mass on the larger wheel.
   - Test their predictions and determine the mass of the counterbalance. (It will be about 40 g.)
   - Set up a teeter-totter system so that it operates the same way that the large and small wheels operate. (Give the students time to invent a system. See Figure 5.8.4[3] and test their predictions on the teeter-totter.)
   - Show how they set up their teeter-totter system and got their answers.
   - Compare the results from the teeter-totter system and the wheel-and-axle systems. (Results will be about the same.)

6. Pose *Problem C*: ***Secure a string on the rim of the 24-cm wheel. Wrap the string twice around the wheel so that the two ends of the string hang down about 20 cm below the wheel on both sides. Attach a 20-g counterbalance to one end and a 10-g counterbalance to the other. Predict what will happen when the two counterbalances are released. Record your prediction and test the system.*** **(See Figure 5.8.4[4]).**

   Ask such questions as these:
   - What did happen? (Get the students' reports.)
   - Which counterbalance pulled the system? Why? (Work to the idea that the 20–g counterbalance pulls the system because there is an unbalanced force pushing on either side of the wheel.)

- How much of the string on the side of the smaller counterbalance was reeled in? (Work to the idea that the same amount as on the larger counterbalance.)

7. **Pose Problem D: *Secure a string on the rim of the 24-cm wheel. Wrap the string twice around the wheel and attach a 20-g counterbalance 20 cm below the wheel. Secure another string on the rim of the 12-cm wheel. Wrap the string once around the wheel and attach a 10-g counterbalance on the opposite side 40 cm below the wheel. Predict what will happen when the two counterbalances are released. Record your prediction and test the system.* (See Figure 5.8.4[5].)**

   Ask such questions as these:
   - What happened? (Get the students' reports.)
   - Which mass pulled the system? Why? (Work toward the idea that the 20-g mass moves down because we have a greater unbalanced force pulling the larger wheel.)
   - How much of the string on the 24-cm wheel ran out? (All of it.)
   - How much of the string of the smaller wheel was reeled in? (About half as much of the string as was unreeled from the larger wheel.)
   - Can we find a rule that tells us which of two wheels of different sizes will reel in or out the most string? (Help the students explore.)
   - What rule did you find? (Work for a general rule like this: When two wheels of different size on the same axle are turning and reeling together, the larger wheel reels or unreels the most, the smaller the least.)
   - Can we make a mathematical rule? (Work for a mathematical rule like this: The amounts of string reeled and unreeled are proportional to the diameters of the wheels. For example, if the diameter of the larger wheel is 24 cm and the diameter of the smaller wheel is 12 cm, the larger wheel will reel or unreel twice the amount of string that the smaller wheel will.)

8. **Have the students explore using their wheel-and-axle systems. Have them predict the relative amounts of string reeled and unreeled when different wheel combinations are allowed to turn.**

EXTENSIONS

Help the students

- Invent a crank to turn their wheel-and-axle systems.
- Invent a way to turn two of more wheel-and-axle systems into connected pulleys. Strings can act as belts. Challenge the students to set up systems in which one turn of one wheel causes another to turn two times, three times, six times, and so forth.

ILLUSTRATIONS

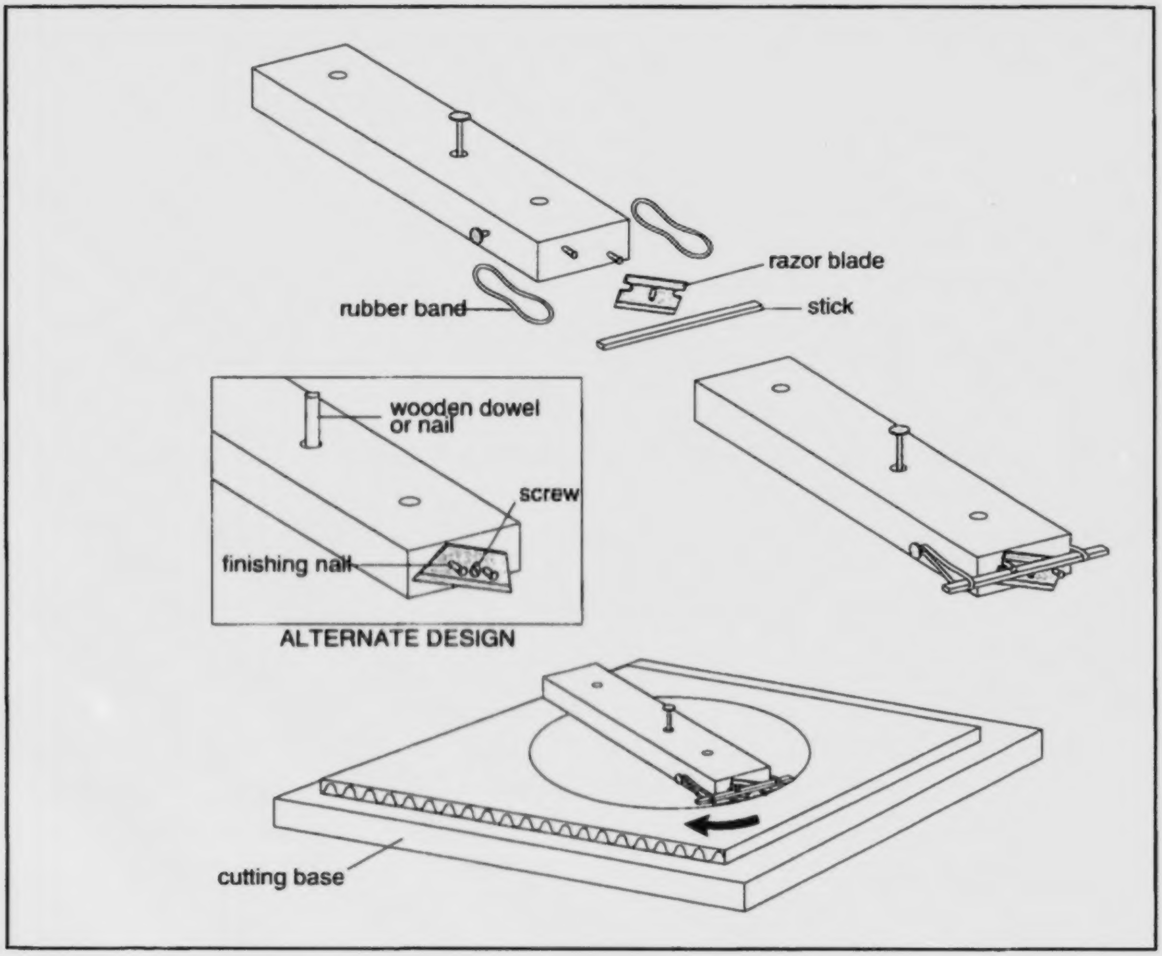
razor blade
rubber band
stick
wooden dowel or nail
screw
finishing nail
ALTERNATE DESIGN
cutting base

Figure 5.8.4(1) Designs for a circle cutter

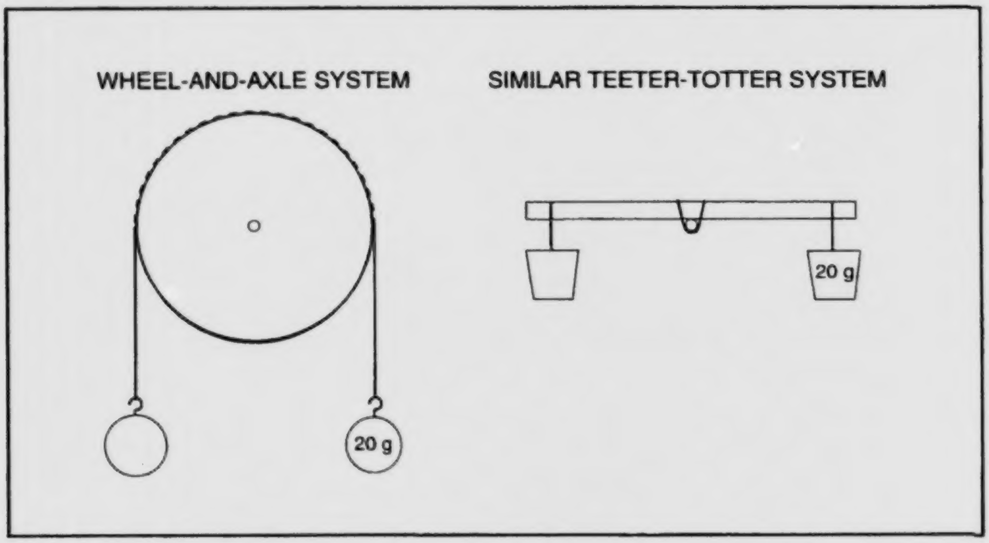
WHEEL-AND-AXLE SYSTEM
SIMILAR TEETER-TOTTER SYSTEM
20 g
20 g

Figure 5.8.4(2) **Problem A.** String, 20-g counterbalance, and a counterbalance of unknown (20-g) mass hung from the 24-cm wheel to produce balance. Also shown is a similar teeter-totter system.

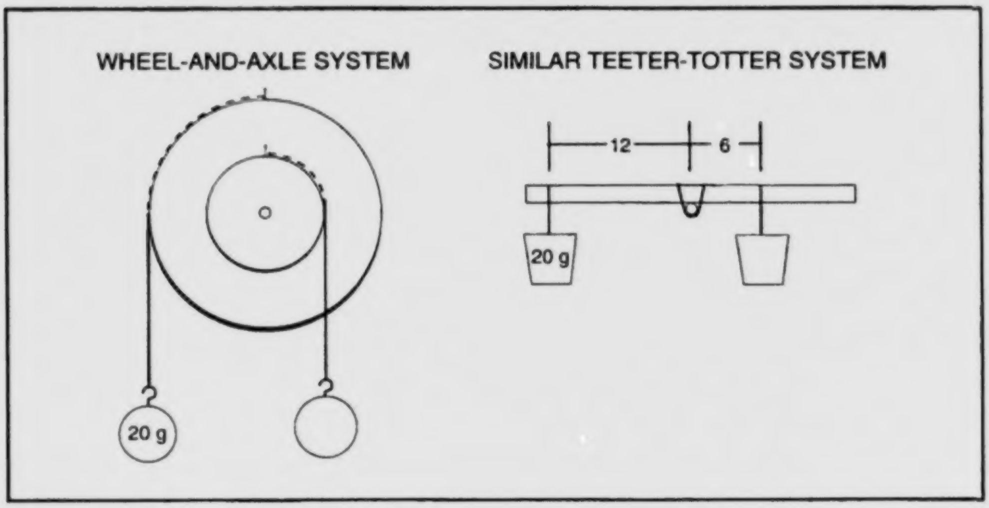
WHEEL-AND-AXLE SYSTEM
SIMILAR TEETER-TOTTER SYSTEM
12
6
20 g
20 g

Figure 5.8.4(3) **Problem B.** String and 20-g counterbalance hung from the 24-cm wheel and string and a counterbalance of unknown (40-g) mass hung from the 12-cm wheel to produce balance. Also shown is a similar teeter-totter system.

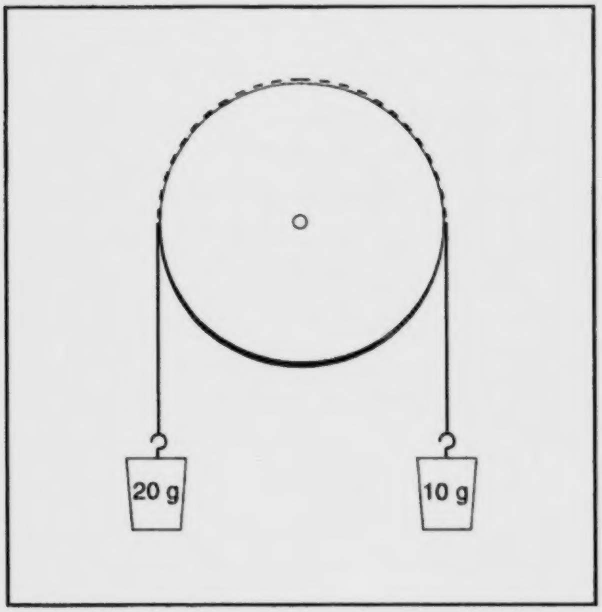

Figure 5.8.4(4) **Problem C.** A string wrapped twice around the 24-cm wheel so that the string hangs down about 20 cm below the wheel on both sides with a 20-g counterbalance on one side and a 10-g counterbalance on the other.

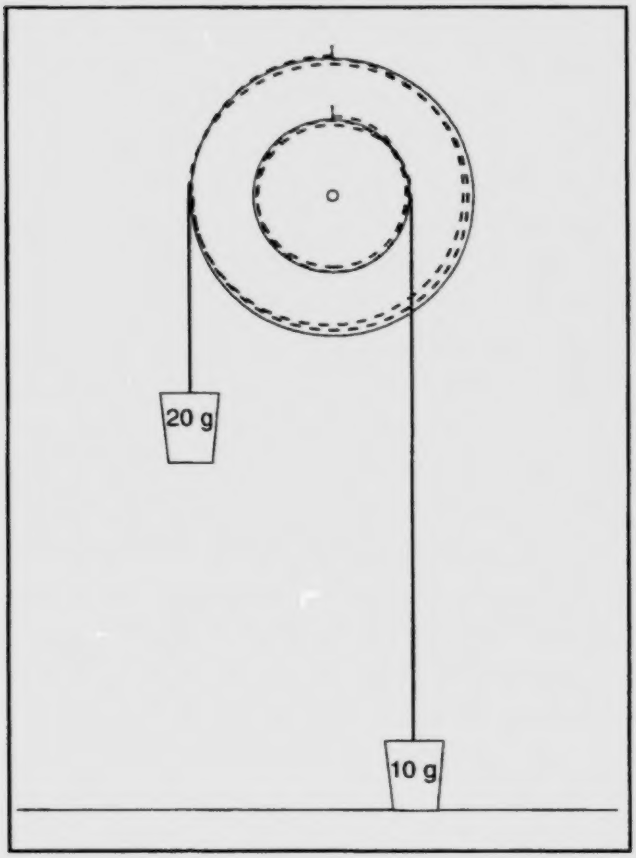

Figure 5.8.4(5) **Problem D.** Showing a string attached and wrapped twice around the 24-cm wheel with a 20-g counterbalance hung 20 cm below the wheel. Also showing a string attached and wrapped twice around the 12-cm wheel with a 10-g counterbalance hung 40 cm below the wheel.

Name________________________

Date________________________

STUDENT PAGE 5.8.4 WHEEL-AND-AXLES

1. **Make a multiple wheel-and-axle system out of cardboard wheels. See Figure SP 5.8.4(1). Use a nail to make a groove in the rim of each wheel. Use the drilled holes to center the wheels and rims and then glue them together.**

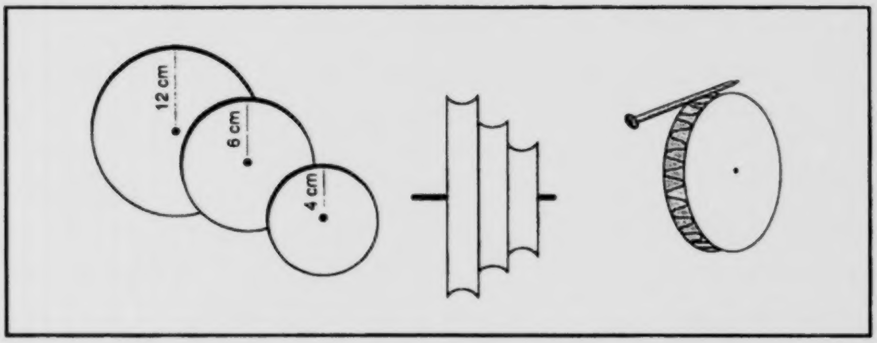

Figure SP 5.8.4(1) Making a wheel-and-axle system

2. **Suspend the system so you can add string and counter-balances easily. Draw your system and describe how you suspended it.**

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Name ______________________

3. **Problem A**: Secure a string on the rim of the 24-cm wheel. Wrap the string around the rim and suspend a 20-g counterbalance from one side. Predict the mass of a counterbalance on the other side that will keep the wheel system from turning. See Figure SP 5.8.4(2). Test the system.

Predicted mass of counterbalance __________

Actual mass of counterbalance __________

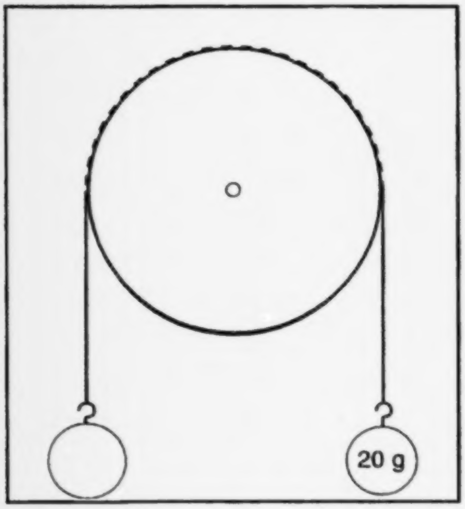

Figure SP 5.8.4(2)
Problem A Showing only the outer wheel

4. **How is this wheel-and-axle system like a teeter-totter system? Draw a similar teeter-totter system and describe the similarities.**

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Name ______________________________

5. **Problem B: Secure a string on the rim of the 24-cm wheel. Wrap the string around the rim and suspend a 20-g counterbalance from one side. Secure another string to the rim of the 12-cm wheel and wrap it around the rim. Predict the mass of a counterbalance needed to keep the wheel system from turning. See Figure SP 5.8.4.(3). Test the system.**

Predicted mass of counterbalance ________________

Actual mass of counterbalance ________________

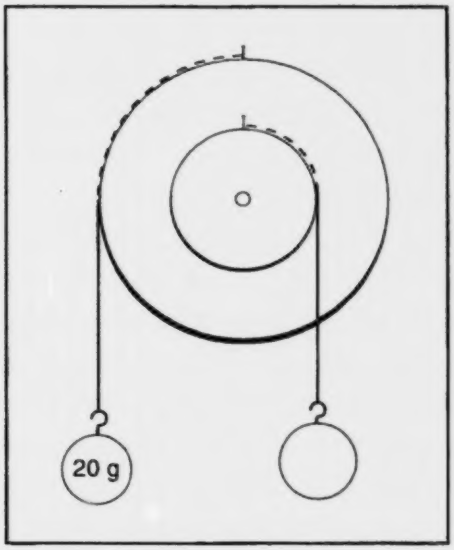

Figure SP 5.8.4(3) Problem B
Showing only the outer and middle wheels

6. **How is this wheel-and-axle like a teeter-totter system? Draw a similar teeter-totter system and describe the similarities.**

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Name ______________________________

7. Problem C: Secure a string on the rim of the 24-cm wheel. Wrap the string twice around the wheel so that it hangs down about 20 cm below the wheel on both sides. Attach a 20-g counterbalance to one end and a 10-g counterbalance to the other. See Figure SP 5.8.4(4). Record what you predict will happen when the two counterbalances are released. Test the system.

Prediction ______________________________

Actual events ______________________________

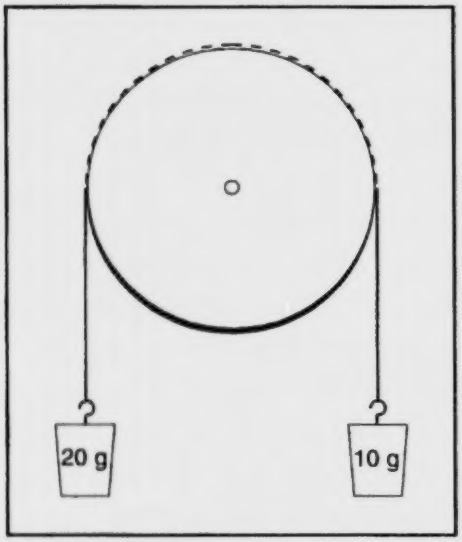

Figure SP 5.8.4(4)
Problem C Showing only the outer wheel

8. Explain how the system operated.

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Name ____________________

9. Problem D: Secure a string on the rim of the 24-cm wheel. Wrap the string twice around the wheel and attach a 20-g counterbalance 20 cm below the wheel. Secure a string on the rim of the 12-cm wheel. Wrap the string twice around the wheel and attach a 10-g counterbalance on the opposite side 40 cm below the wheel. Record what you predict will happen when the two counterbalances are released. See Figure SP 5.8.4(5).

Prediction ____________________

Actual events ____________________

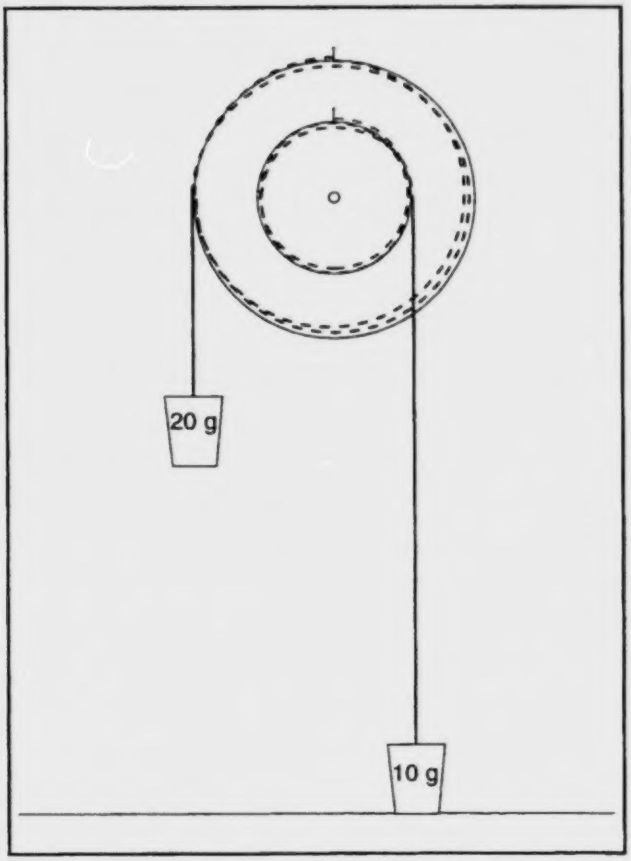

Figure SP 5.8.4(5)
Problem D Showing only the outer and middle wheels

Name ______________________

10. Explain how the system operated.

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11. Experiment with your wheels and axles and develop a rule to predict how much string will be unreeled by one wheel as another wheel reels it in.

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ACTIVITY 5.8.5 LEVERS: WHERE ARE THEY?

OBJECTIVES

The students
- Identify the characteristics of wheel-and-axle systems.
- Draw levers that are similar to wheel-and-axle systems.
- Classify levers as first-, second-, and third-class by location of the fulcrum, resistance, and effort.
- Identify the class of lever found in selected devices.

BACKGROUND

This is an activity in the simple machine series and should follow Activities 5.8.1 PUSHES, PULLS, AND FORCES, 5.8.3 THE BALANCE, and 5.8.4 WHEEL-AND-AXLES. In LEVERS: WHERE ARE THEY? the students identify the characteristics of various wheel-and-axle systems. They then draw levers that are similar to the wheel-and-axle systems and find that there are only three types of levers. They are told that these three types are called *first-*, *second-*, and *third-class* levers. The teeter-totter that they used throughout Activity 5.8.4 WHEEL-AND-AXLES is found to be a first-class lever. Finally, the students are asked to identify the classes of levers found in common tools.

Wheel-and-Axle Systems

Table SP 5.8.5-1 shows five different wheel-and-axle systems. The students can make these using the wheel-and-axle setups they used in Activity 5.8.4 WHEELS AND AXLES. They can get a sense of the relative effort needed to pull the resistance by using the force-measuring instrument from Activity 5.8.1 PUSHES, PULLS, AND FORCES.

Fulcrum, Resistance, and Effort

Levers have three points of operation along their length. These are the *fulcrum*, the point around which the lever rotates; the *resistance*, the point where the object being moved is located; and the *effort*, the point where force is applied to move the object.

Classes of Levers

The fulcrum, resistance, and effort can be distributed along the beam of a lever in three different ways. All *first-class* levers have their *fulcrum* between the effort and the resistance. All *second-class* levers have their *resistance* between the fulcrum and effort, and all *third-class* levers have their *effort* between the fulcrum and the resistance. This leads to a mnemonic to help remember these distributions:

From the middle we see
Of classes 1, 2, 3
That levers are F-R-$\bar{\text{E}}$

The numbers ***1, 2, 3*** refer to the class associated with the Fulcrum, Resistance, and Effort when they occupy the *middle position* on the beam. Pronounce the *E* as a long *E*. The mnemonic "F-R-E" becomes "free."

STUDENT ROLES

Physicist
Mechanical engineer

MATERIALS

wheels and axles from Activity 5.8.4 WHEEL-AND-AXLES
counterbalances from Activity 5.8.3 THE BALANCE
force-measuring instrument from Activity 5.8.1 PUSHES, PULLS, AND FORCES
Student Page 5.8.5 LEVERS

PRODUCTS

Completed Student Pages

PROCEDURES

1. **Give the students Student Page 5.8.5 LEVERS and help them set up the wheel-and-axle systems shown in Table SP 5.8.5-1 and Figure SP 5.8.5(2). Help them determine whether the effort represented by the hand is *greater*, the *same as*, or *less than* the resistance produced by the 20-g mass represented by the circle on the string. Have the students use the force-measuring instruments from Activity 5.8.1 PUSHES, PULLS, AND FORCES.**

   Ask such questions as these:
   - What are the differences in the systems? (Develop such things as the location of the hands and the thing being moved. Give the hand

symbol the formal name *effort force*, the object being moved the name *resistance force*, and the pivot the name *fulcrum*.)

- In which of the systems is the effort more than the resistance? (Work for agreement that in Systems 3 and 5 the effort is greater.)
- In Systems 3 and 5 how does the distance from the fulcrum to the resistance compare with the distance from the fulcrum to the effort? (Work for agreement that the resistance in both systems is farther from the fulcrum than the effort.)
- Of all the systems, in which is the effort less than the resistance? (Work for agreement that in their investigations the effort is less than the resistance in Systems 2 and 4.)
- In Systems 2 and 4 how does the distance from the fulcrum to the resistance compare with the distance from the fulcrum to the effort? (Work for agreement that the effort is farther from the fulcrum than the resistance.)
- How do the resistance and the effort compare in System 1? (Here the effort and the resistance are the same.)
- In System 1 how does the distance from the fulcrum to the resistance compare with the distance from the fulcrum to the effort? (Work for agreement that they are the same.)
- Under what conditions is the effort the greatest? (Work for agreement that it is the greatest when it is closest to the fulcrum.)
- Under what conditions is the resistance the greatest? (Work for agreement that it is the greatest when it is closest to the fulcrum.)
- Why are the effort and the resistance both called forces? (Get at the idea that they are either pushes or pulls, and pushes and pulls are forces.)
- What generalization can we make about distance from the fulcrum and the relative amount of resistance and effort forces? (Work for agreement that the force [effort or resistance] that is closest to the fulcrum will always be the larger.)

2. **Compare wheel-and-axle systems with levers. Have the students use Figure SP 5.8.5(2).**

Ask such questions as these:

- A teeter-totter is really a lever. What would be a working definition of a lever? (Get at something like this: A lever has a piece that does not move such as a beam, stick, or ruler. It rotates around a fulcrum, and we apply forces to it on either side of the fulcrum.)

- How is the wheel-and-axle in System 1 like our teeter-totter? Like a lever? (Work to the idea that we have a downward force on either side of a teeter-totter and it turns around a fulcrum. There is also a downward force on either side of the wheel-and axle in System 1 that turns around a fulcrum.)
- How could we show on the drawing that the wheel-and-axle is similar to the teeter-totter? (Work to the idea that we can draw a straight line through the wheel-and-axle from the effort to resistance. Have the students draw such a line.)
- Which other wheel-and-axle systems are like the teeter-totter? (Work for agreement that Systems 1, 2, and 3 are all like the teeter-totter.)
- How would a lever that is similar to the wheel-and-axle shown in System 4 differ from a teeter-totter? (Probe for the idea that this lever would have the resistance between the fulcrum and the effort. The resistance has taken the place of the fulcrum.)
- How would a lever that is similar to the wheel-and-axle shown in System 5 differ from a teeter-totter? (Probe for the idea that this lever would have the effort between the fulcrum and the resistance. The effort has taken the place of the fulcrum.)

3. **Help the students label the fulcrum (F), the resistance (R), and the effort (E) on lever systems that are similar to the wheel-and-axle systems in Figure SP 5.8.5(2). See Figure 5.8.5(1).**

4. **Help the students draw combinations of the locations of the effort, fulcrum, and resistance. See Student Page 5.8.5, Item 4.**

Ask the students such questions as these:

- How many combinations of the fulcrum, resistance, and effort were you able to draw? (They should be able to draw six combinations: **R–F–E, E–F–R, F–R–E, E–R-F, F–E–R** and **R–E–F**.)
- How many different combinations are there with the fulcrum **(F)** at the mid-point? (Work to the observation that there are two: **R–F–E** and **E–F–R**.)
- It has been said that these two combinations (**R–F–E** and **E–F–R)** are the same. How might this be true? (Have the students make

R–F–E and **E–F–R** levers and notice that one can be turned into the other by simply moving the lever around. A pencil with a finger fulcrum can be used. Let the point be the effort.)

- Can **F–R–E** and **E–R-F** combinations also be seen as being the same? (Have the students use a pencil model and verify that they are the same and are only reversed in the drawing. Then have them verify that the combinations **F–E–R** and **R–E–F** are the same.)
- In the real world of levers how many different combinations do we have? (Work to the idea of three combinations.)

5. **For purposes of identification, levers are classified as first class, second class, and third class. In each diagram in Figure SP 5.8.5(3) the class of the levers has been identified. Help the students label the effort (E), fulcrum (F), and resistance (R). See Figure 5.8.5(2).**

   Ask such questions as these:
   - What is found in the mid-part of the first class lever, the fulcrum, resistance, or effort? (The fulcrum.)
   - What is found in the mid-part of the second-class lever, the fulcrum, resistance, or effort? (The resistance.)
   - What is found in the mid-part of the third-class lever, the fulcrum, resistance, or effort? (The effort.)
   - Were you able to draw any other combinations of the fulcrum, resistance, and effort? (Work for agreement that they were not.)

6. **Help the students interpret the mnemonic**

   From the middle we see
   Of classes 1, 2, 3
   That levers are F-R-E

   Ask such questions as these:
   - What is in the middle of the **1**st-class lever? (First class levers have the **F**ulcrum in the middle.)
   - What is in the middle of the **2**nd-class lever? (Second-class levers have the **R**esistance in the middle.)
   - What is in the middle of the **3**rd-class lever? (Third-class levers have the **E**ffort in the middle.)

7. **Have the students return to Figure SP 5.8.5(2) and label the class of lever shown. See Figure 5.8.5(1).**

8. **Help the students label the lever systems shown Figure SP 5.8.5(3) to show their class, the effort (E), fulcrum (F), and resistance (R). Have them use arrows to show the direction of the forces. See Figure 5.8.5(3).**

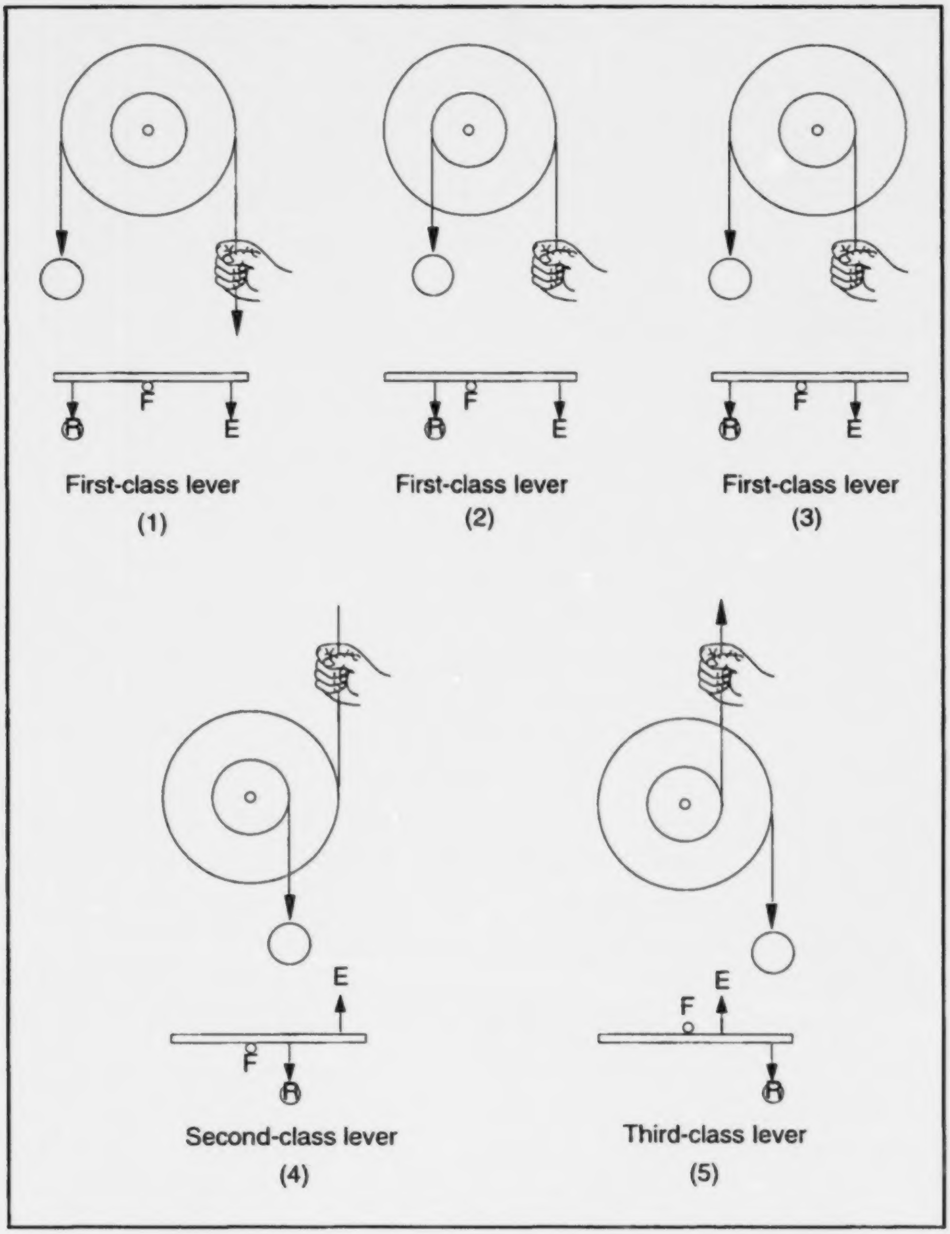
• scissors	(first-class)
• crowbar lifting a stone	(first-class)
• nutcracker	(second-class)
• wheelbarrow	(second-class)
• drawbridge	(third-class)
• shovel lifted in the middle	(third-class)

EXTENSIONS

Have the students

- Go on a search of the classroom and playground to find as many examples of levers as they can. Help them draw the levers they find and classify them.
- Start a Book of Machines.
- Make a bulletin board display of levers.

ILLUSTRATIONS



First-class lever (1)

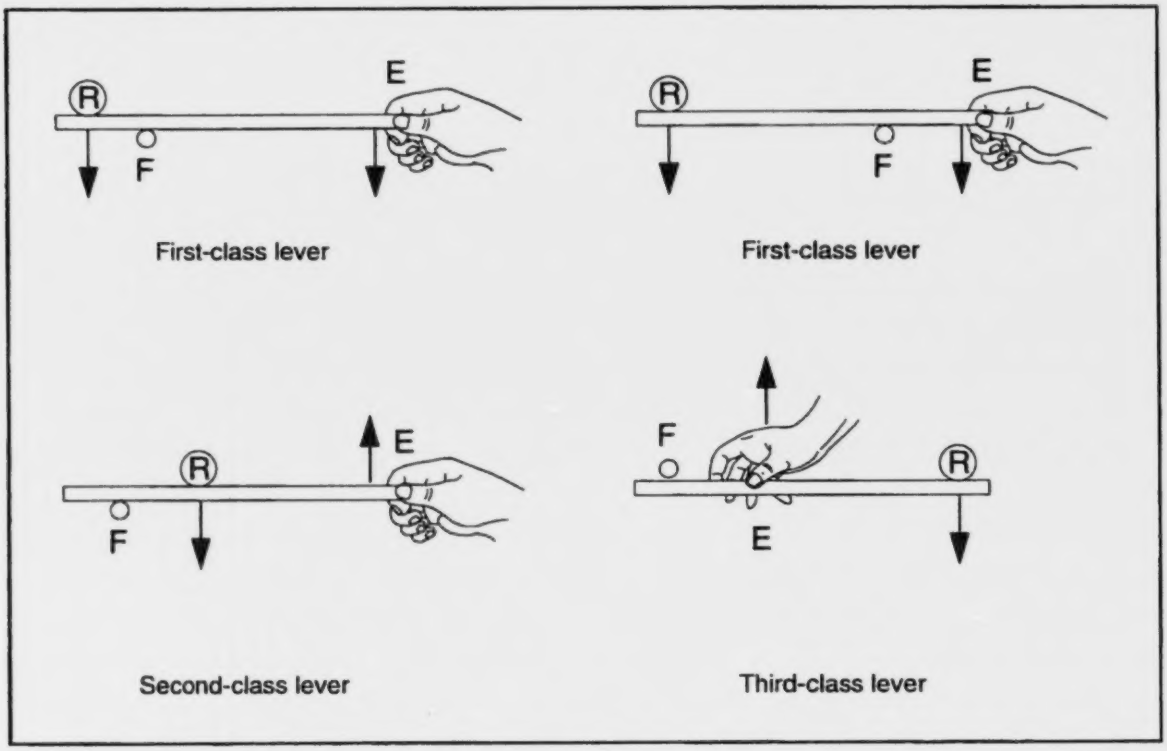
First-class lever (2)

First-class lever (3)

Second-class lever (4)

Third-class lever (5)

Figure 5.8.5(1) Wheel-and-axle systems with a hand representing effort, a circle on the string resistance, and a small circle the fulcrum. Also shown are similar lever systems with the fulcrum (F), resistance (R), and effort (E) labeled and the direction of forces indicated by arrows. All systems are balanced.



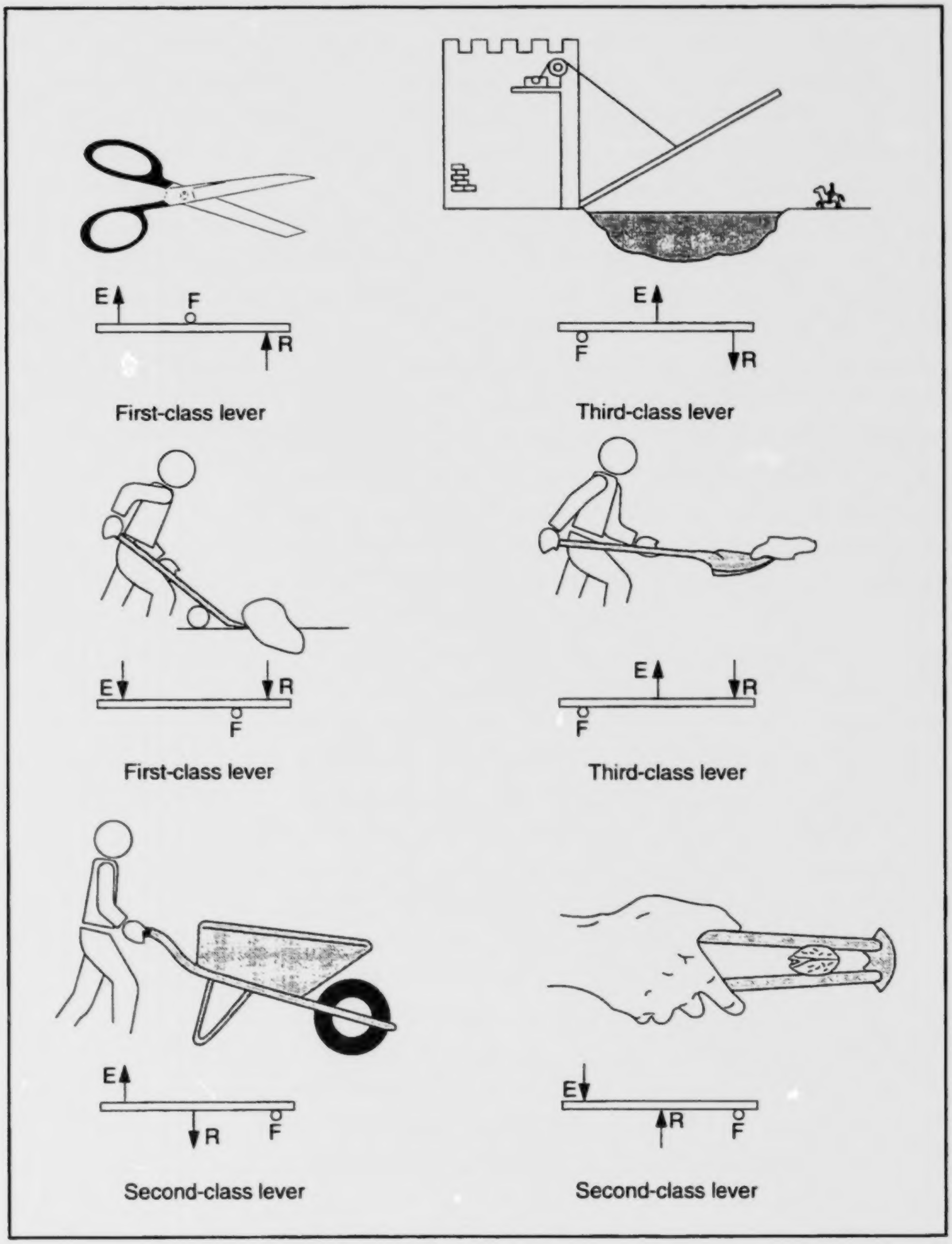
First-class lever

First-class lever

Second-class lever

Third-class lever

Figure 5.8.5(2) First-, second-, and third-class levers showing the fulcrum (F), resistance (R), and effort (E) with the direction of forces indicated by arrows.



First-class lever

Third-class lever

First-class lever

Third-class lever

Second-class lever

Second-class lever

Figure 5.8.5(3) Various machines, the class of lever they represent, the location of the fulcrum (F), resistance (R), and effort (E), and the direction of forces indicated by arrows.

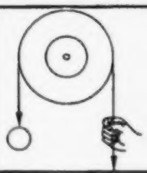
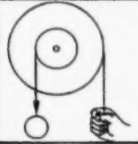
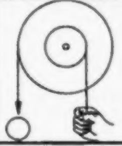
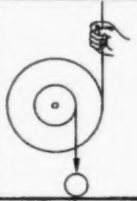
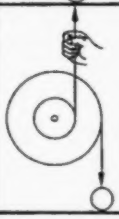
Name________________________

Date________________________

STUDENT PAGE 5.8.5 LEVERS

1. Use Table SP 5.8.5-1 as a guide to set up the wheel-and-axle systems shown. Use a 20-g mass to produce a resistance (R) and determine whether the effort (E) force represented by the hand is *greater than, the same as,* or *less than* the resistance force represented by the circle. Check (✓) the appropriate cell in the table.

Table SP 5.8.5(1) Wheel-and-axle systems

		E more than R	E less than R	E same as R
System 1				
System 2				
System 3				
System 4				
System 5				

Name ______________________________

2. On the similar lever system shown under each wheel-and-axle system in Figure SP 5.8.5(2) label the fulcrum with an (F), the resistance with an (R), and the effort with an (E).

3. In Figure SP 5.8.5(3) label the fulcrum with an (F), the resistance with an (R), and the effort with an (E).

4. There are three different locations on a lever. One is a mid-location, and there are two outside or end locations. Keeping these three locations in mind, draw all possible combinations of locations of the fulcrum (F), resistance (R), and effort (E) on the lever beams below.

_______________ _______________ _______________

_______________ _______________ _______________

_______________ _______________ _______________

Total number of possible drawing combinations ___

Total number of different actual combinations ___

5. Explain how the mnemonic below helps identify the different classes of levers.

From the middle we see
Of classes 1, 2, 3
That levers are F-R-Ē

____

____

____

____

Name ______________________________

6. **Label the class of the levers similar to the wheel-and-axle systems shown in Figure SP 5.8.5(2).**

7. **Label the class of the levers operating in the machines shown in SP 5.8.5(4). Label the levers to show the fulcrum (F), resistance (R), and effort (E). Use arrows to show the direction of the effort and resistance.**

ILLUSTRATIONS

Name ______________________

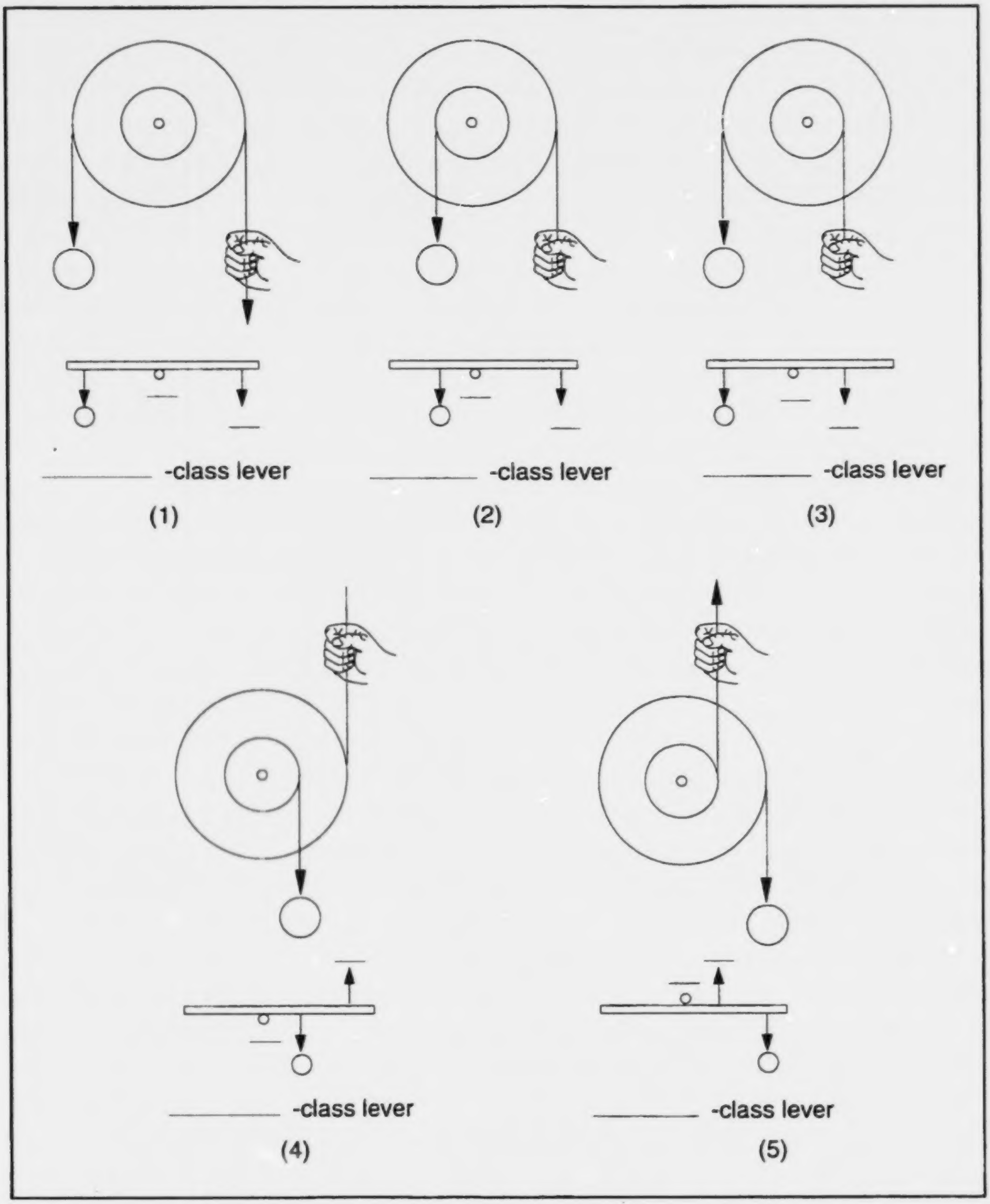
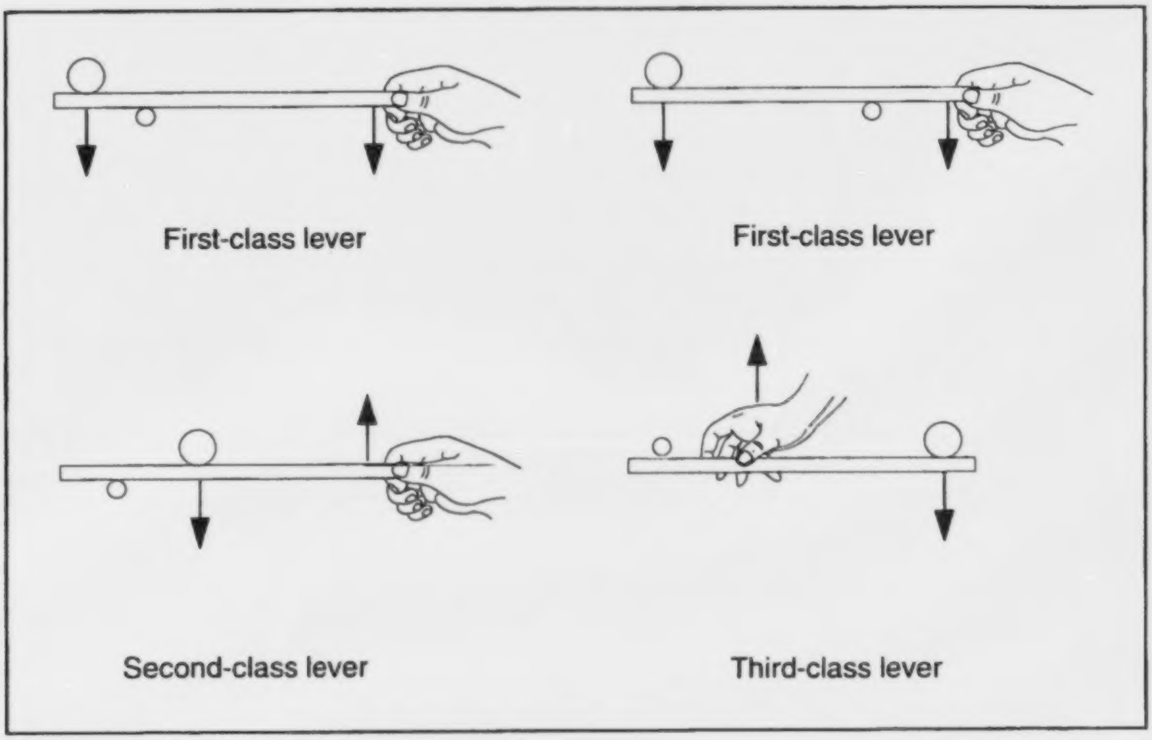

______ -class lever
(1)
______ -class lever
(2)
______ -class lever
(3)
______ -class lever
(4)
______ -class lever
(5)

Figure SP 5.8.5(2) Wheel-and-axle systems with a hand representing the effort, a circle on the string the resistance, and a small circle the fulcrum. All systems are balanced. Similar lever systems are shown.

Name ______________________________



First-class lever

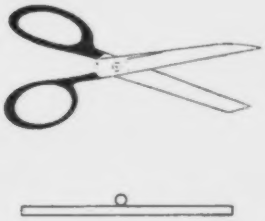
First-class lever

Second-class lever

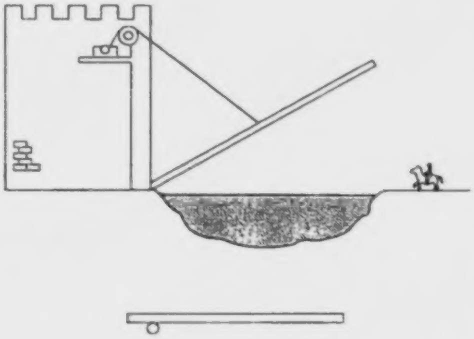
Third-class lever

Figure SP 5.8.5(3) First-, second-, and third-class levers. All levers are balanced

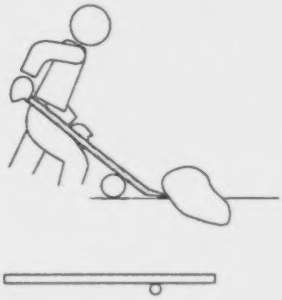
Name ______________________



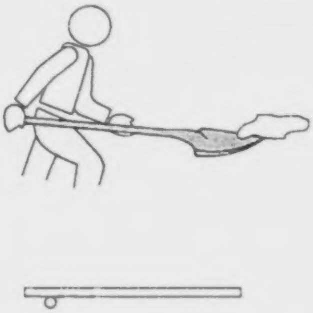
______ -class lever



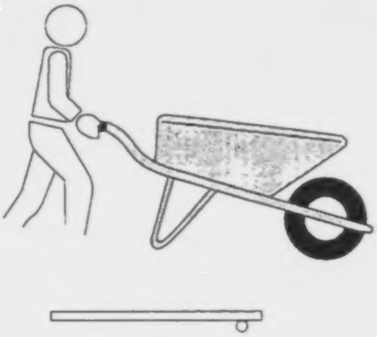
______ -class lever



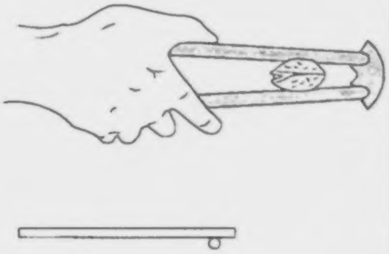
______ -class lever



______ -class lever



______ -class lever



______ -class lever

Figure SP 5.8.5(4) Various machines

ACTIVITY 5.8.6 ARMS AND JAWS

OBJECTIVES

The students
- Identify where muscles are attached to selected bones.
- Make working models of selected muscle-bone systems.
- Identify the classes of levers represented in selected muscle-bone systems.

BACKGROUND

This is one of the activities in the simple machine series. It should follow 5.8.1 PUSHES, PULLS, AND FORCES, 5.8.2 TEETER-TOTTERS, 5.8.5 LEVERS: WHERE ARE THEY? 5.3.13 SKELETAL SYSTEM, 5.3.14 MUSCLES, and 5.3.15 MUSCULAR SYSTEM. In ARMS AND JAWS the students explore the connections of bones to muscles and how muscles cause bones to move. They make working models of these muscle-bone systems, find that the systems work as levers, and then identify the kinds of levers the systems represent.

Bone Attachment

The students find where muscles are attached to their bones by feeling them as they did in Activity 5.3.14 MUSCLES. This is easier to do when they work their muscles against a resistance. For example, in finding the muscles that open the jaw, if the students hold their jaws closed with heel of their hand as they try to open their mouth, the muscles under their jaw will become more obvious as they tighten and swell.

Examination of the hand and the upper arm near the elbow will reveal that muscles are attached to bones by rope-like tendons. A tendon is very apparent at the point where the biceps attaches to the radius. Tendons connecting the muscles of the forearm to the fingers can be felt in the palm and the back of the hand when the fingers are tensed.

Models and Muscle-Bone Systems

This is an open-ended opportunity for invention. A simple model of the head and jaw can be made by attaching the cutout of the skull to a sheet of cardboard and pinning the jaw to it at the fulcrum or pivot. Thread or string can be used to operate the jaw. The humerus can also be attached to cardboard and the radius and ulna tacked to pivot on the humerus. Again, string or thread can be used to simulate muscles and tendons. Interesting alternative models can be made out of sticks using rubber bands for joints and string for muscles and tendons.

Finger models can be made out of cardboard with joints of tape, string, brads, and so forth. String tendons can be passed through thread loops attached with tape. Once the models are working, have the students compare them and relate them to their own body.

The finger model is intended to give the students a sense of how fingers might operate as levers. Do not be concerned that muscle-bone systems actually operate as second- and third-class levers. Depending on the construction, the classes of levers represented by different models will vary. It is important only that the students be able to identify the classes of levers operating in the models they make.

STUDENT ROLES

Physiologist
Anatomist

MATERIALS

brads
bucket
cardboard
chopsticks
rubber bands
string
plastic straws
scissors
tacks or pins
tape
Student Page 5.8.6 ARMS AND JAWS

PRODUCTS

Models of muscle-bone systems
Completed Student Pages

PROCEDURES

1. **Introduce the activity by having the students clamp their jaws shut and feel the muscles that hold the jaws shut.**

Ask such questions as
- Where are the muscles you can feel when you clamp your jaws shut? (At the back of the jaw and in the temporal area of the skull.)
- Where do they appear to be attached? (On the back of the jaw and in the temporal area of the skull. As might be expected, there are several different muscles involved in closing the jaw, but they appear to be one.)
- What muscles open your jaw? (Those below the jaw, starting at the front of the jaw and extending back into the neck. Ultimately, they are attached to the spine.)
- Where does the fulcrum or pivot of the jaw appear to be? (This is a sliding pivot at the rear of the jaw that can be felt to slide by moving the jaw from side to side.)

2. **Hand out Student Page 5.8.6 ARMS AND JAWS and help the students make a working model of the jaw.**

Help the students
- Cut out the jaw and attach the skull to a sheet of cardboard or other solid surface.
- Attach the jaw to the skull at the pivot or fulcrum using their own jaw and skull as a guide. Use tacks, tape, and so forth, so that the jaw will pivot. See Figure 5.8.6(1).
- Invent ways to operate the jaw using string, rubber bands, or other material.
- Identify the class of lever operating when the jaw is closed. (Third class.)
- Identify the class of lever operating when the jaw is opened. (Second class.)

3. Help the students make a working model of the muscle-bone systems operating their arm. See Figure 5.8.6(2).

Have the students

- Locate where the radius and ulna of their forearm are attached to the humerus or upper arm bone.
- Locate the muscle that raises the forearm by lifting a book. (This is the biceps.)
- Look up the definition of a tendon. (Work to agreement that a tendon is a cord or band of dense tissue connecting muscles to bone or other muscles.)
- Locate the tendon that attaches the biceps to the radius.
- Locate where the biceps is attached to the body. (This will be in the shoulder area.)
- Invent a string, rubber band, or other simulated muscle-tendon system to lift the forearm.
- Identify the class of lever operating when the forearm is lifted. (Third class.)
- Locate the muscle that restores the forearm to its straightened position when the fist pushes down on an object. (This is the triceps on the underside of the upper arm.)
- Locate where this muscle is attached to the body. (This will be in the shoulder area.)
- Invent simulated muscles and tendons to straighten the arm.
- Identify the class of lever operating when the arm is straightened. (First class.)

4. Have the students assemble a working model of the fingers.

Help them

- Find and count the bones in their index finger and thumb.
- Locate the muscles that close the fingers. (These are the muscles found in the under or palm side of the forearm. The finger-opening muscles are in the upper or back-of-the-hand side of the forearm.)

- Locate where the forearm muscles are attached to the radius and the ulna. (At the elbow.)
- Locate where the finger bones are attached to the wrist bones. (The students can find wrist bones in their model of the skeleton from Activity 5.3.13 SKELETAL SYSTEMS.)
- Locate the tendons attaching the forearm muscles to the finger bones by tensing the fingers and feeling the back of the hand, the palm of the hand, and the fingers.
- Invent a string muscle-tendon system to close the index finger and the thumb on each other. (The students may need to back their cutouts with cardboard. They can use tape or other materials for pivots. They may wish to make wrist bones.)
- Invent a simulated muscle-tendon system that will open the fingers.
- Identify the class of lever operating when the finger of the model is opened. (When the model finger shown in Figure 5.8.6[3] is opened, the bones operate as third-class levers. Note that the students may use different lever systems in their invented systems. If this happens, discuss the advantages of having different lever classes in the fingers. Point out that mechanical "fingers" are used in many machines.)
- Identify the class of lever operating when the finger of the model is closed. (When the model finger shown in Figure 5.8.6[3] is closed, the bones operate as second-class levers. Again the students may have different lever systems in their invented systems and so have different classes of levers operating.)

5. **Show the students how to cut *V*-cuts or notches in a plastic straw to represent the bones of the index finger. Help them attach a string to the tip segments. Have them pull the string. See Figure 5.8.6(4).**

Help the students

- Explain how their own finger is similar to and different from the plastic straw model. (Work to the idea that they operate the same way, but the string representing a tendon is attached to only one finger bone in the straw model.)
- Explain how the straw-model finger is straightened when tension on the string is relaxed. (Work to the idea that the elastic property of the straw straightens the plastic finger, but we must use tendons and muscles to open our real fingers.)

6. Summarize the activity.

Ask such questions as these:

- How much do muscles move when they contract? (Get at the idea that they do not move very much. Help the students measure how much the biceps moves when they raise their forearm. It will probably be less than an inch or 2.5 cm.)
- What are the advantages of having the biceps and its tendon attached close to the elbow or pivot? (Work to the idea that for a small amount of movement of the biceps we produce a lot of movement in our hand. Have them also notice that it takes a lot of effort to get this movement.)
- At which location could we lift a bucket of water with the least effort—with the bail placed in the palm of our hand or with the bail placed 10 cm from our elbow? (This should be tested. It will take much less effort to lift a bucket of water when the bail is placed 10 cm from the elbow than when it is placed in the palm of the hand. Because we do not have to lift the bucket as far, less effort is required.)
- Why are the tendons used in opening and closing the fingers so long? (Work to the idea that it is because the muscles operating the hand are in the forearm, which is some distance from the fingers.)
- How is our body like a machine? (Work to the idea that the skeleton and muscles operate as a lever system—a kind of simple machine.)

EXTENSIONS

- Challenge the students to invent mechanical fingers that use each class of lever.
- Have the students make working models of additional muscle-bone systems of the body.

ILLUSTRATIONS

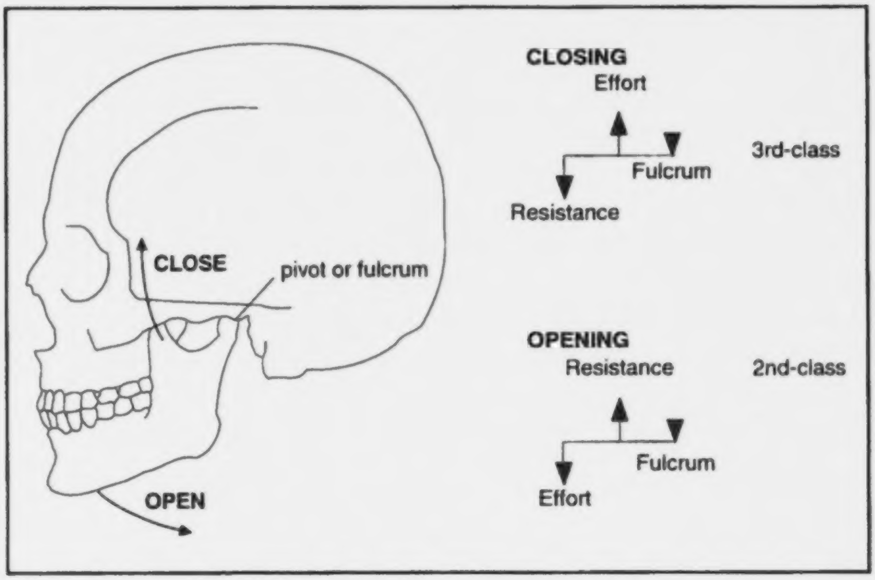

CLOSING
Effort
Fulcrum
3rd-class
Resistance
CLOSE
pivot or fulcrum
OPENING
Resistance
2nd-class
Fulcrum
Effort
OPEN

Figure 5.8.6(1) Opening and closing of the jaw using a string model. Examples of second- and third-class levers.

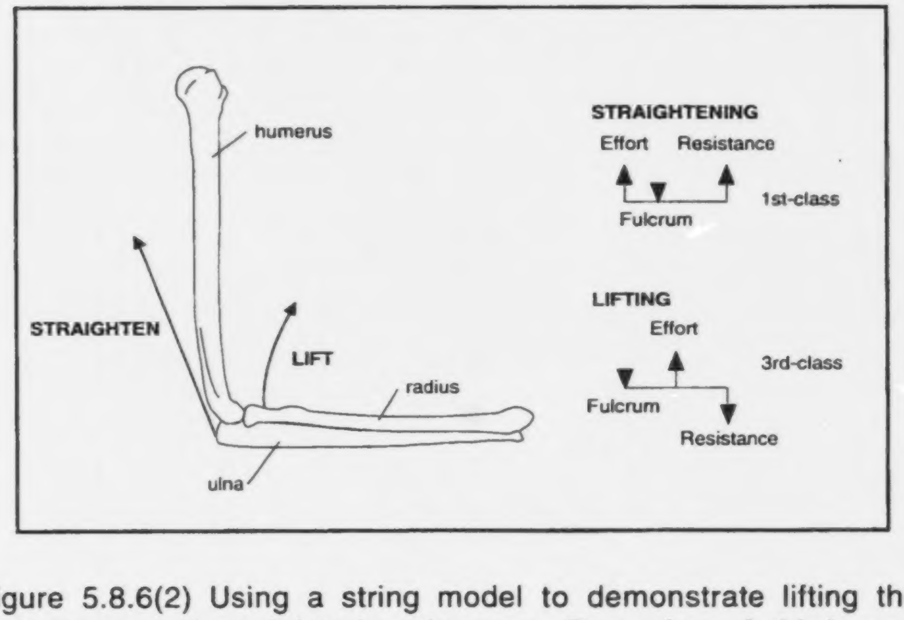

humerus
STRAIGHTENING
Effort
Resistance
1st-class
Fulcrum
LIFTING
Effort
3rd-class
Fulcrum
Resistance
STRAIGHTEN
LIFT
radius
ulna

Figure 5.8.6(2) Using a string model to demonstrate lifting the forearm and straightening the arm. Examples of third- and first-class levers.

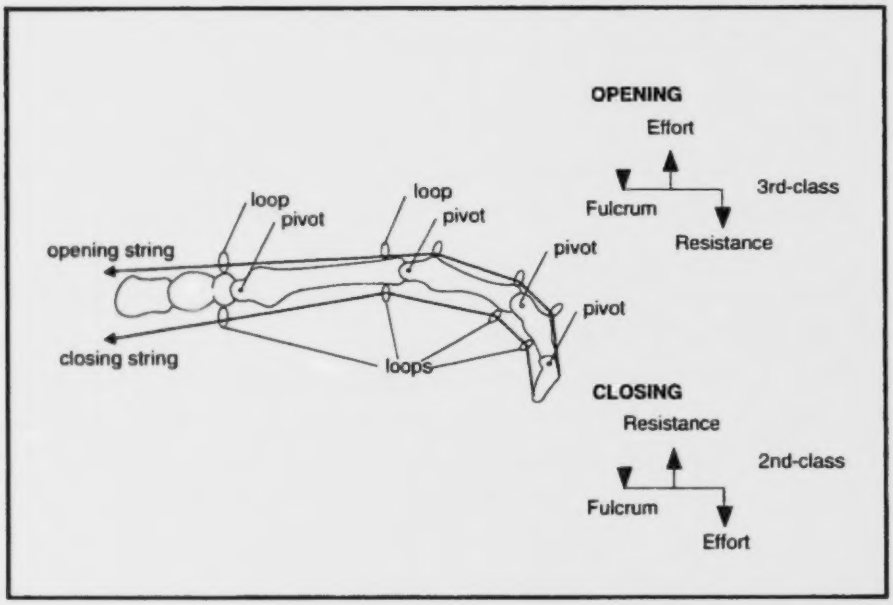

OPENING
Effort
3rd-class
Fulcrum
Resistance
loop
pivot
loop
pivot
opening string
pivot
pivot
closing string
loops
CLOSING
Resistance
2nd-class
Fulcrum
Effort

Figure 5.8.6(3) String model of the index finger showing pivot points and loops to thread a simulated tendon. Examples of second- and third-class levers.

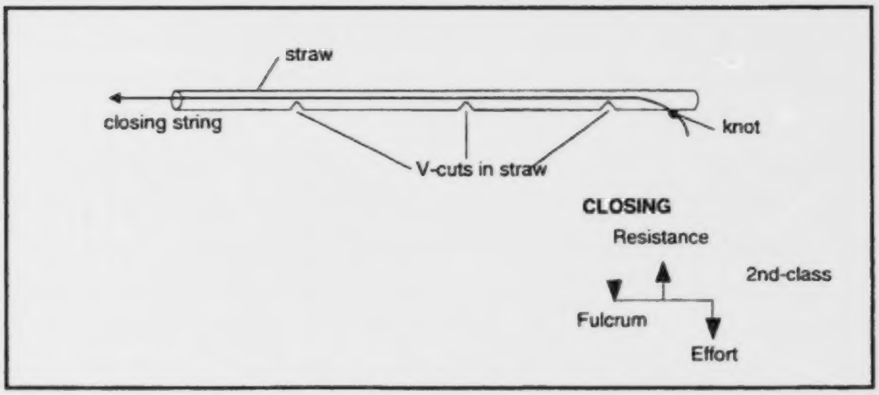

straw
closing string
knot
V-cuts in straw
CLOSING
Resistance
2nd-class
Fulcrum
Effort

Figure 5.8.6(4) Plastic-straw model of a finger

DASH

Name ____________________

Date ____________________

STUDENT PAGE 5.8.6 ARMS AND JAWS

1. Cut out the bones shown in Figure SP 5.8.6(1) and assemble them into a working model of the jaw.

2. Identify the class of lever operating in the muscle-bone systems when the jaw is *opened.*

   ____

3. Identify the class of lever operating in the muscle-bone systems when the jaw is *closed.*

   ____

4. Cut out the bones on Figure SP 5.8.6(2) and assemble them into a working model of the arm.

5. Identify the class of lever operating when the forearm is *lifted* by the biceps.

   ____

6. Identify the class of lever operating when the forearm is restored to its *straightened* position by the triceps.

   ____

7. Cut out the bones in Figure SP 5.8.6(3) and assemble them into a working model of the index finger and thumb.

8. Identify the classes of levers operating to *open* your model fingers.

   ____

Name ______________________________

9. **Identify the classes of levers operating to *close* your model fingers.**

____

10. **Follow your teacher's instruction and make a plastic-straw model of a finger.**

11. **Explain how your straw model of a finger is similar to and different from your actual finger.**

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12. **Identify the class or classes of levers operating to *open* your plastic-straw model of a finger.**

____

13. **Identify the class or classes of levers operating to *close* your plastic-straw model of a finger.**

____

ILLUSTRATIONS

Name ______________________________

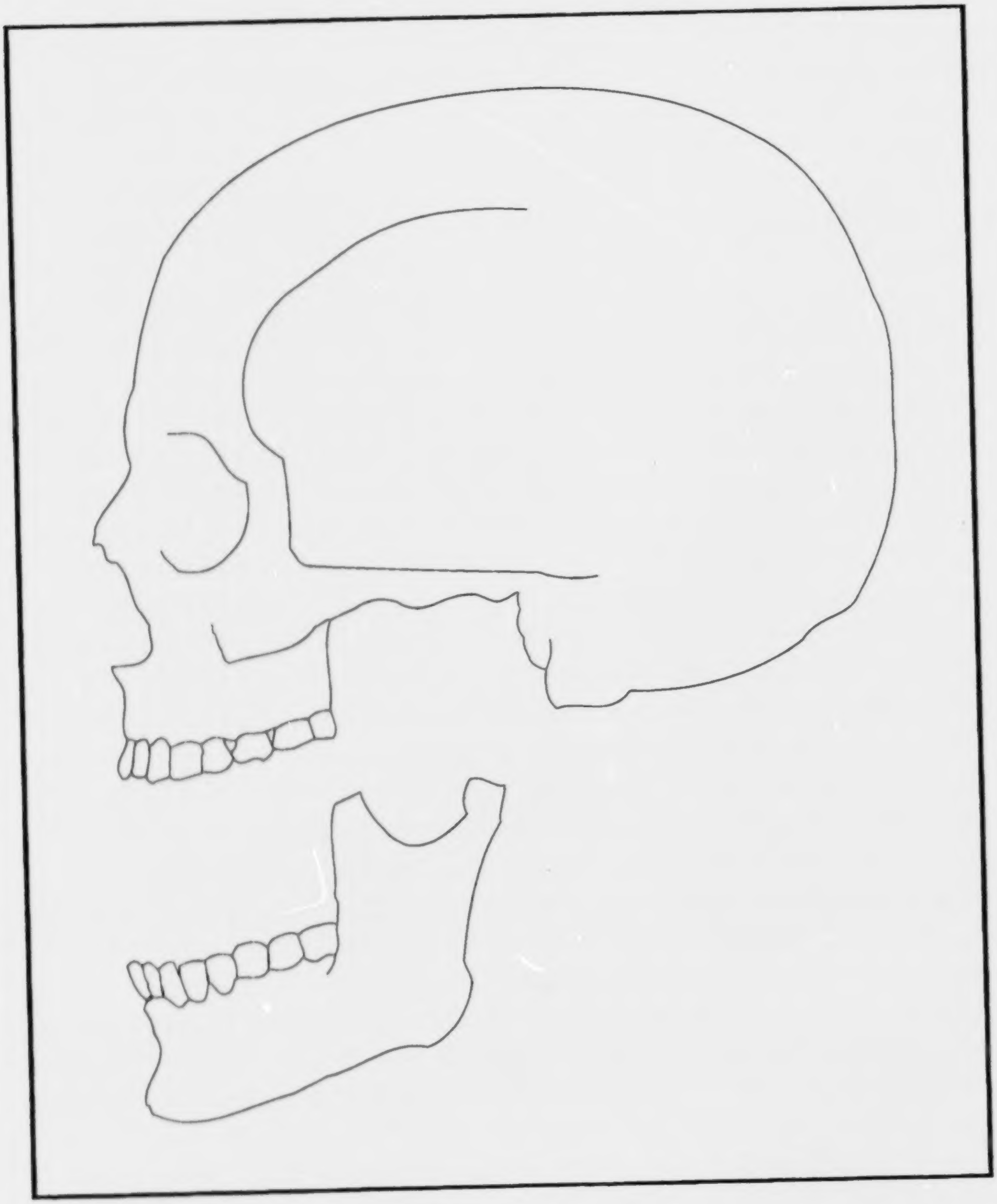

Figure SP 5.8.6(1) Skull and jaw bones

Name ______________________________

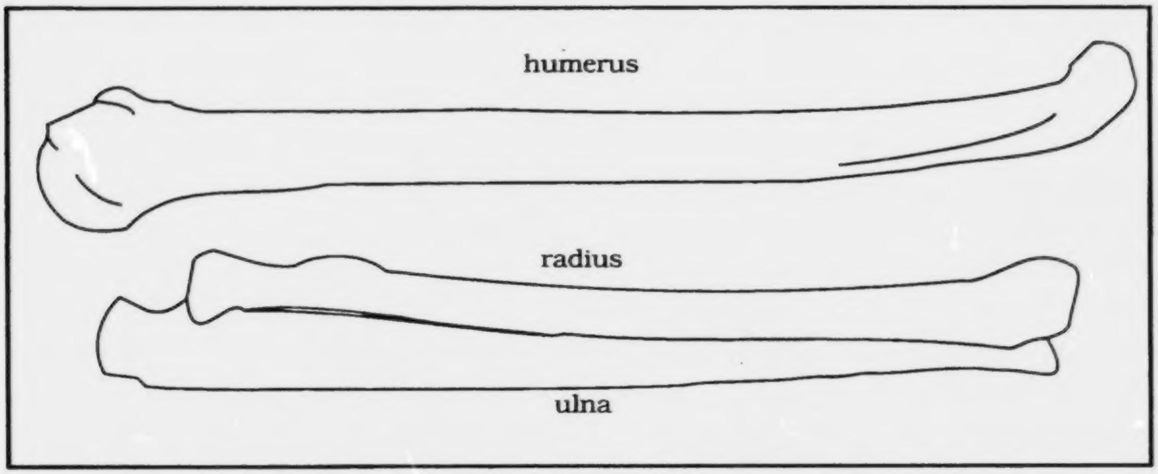
humerus
radius
ulna

Figure SP 5.8.6(2) Humerus, radius, and ulna

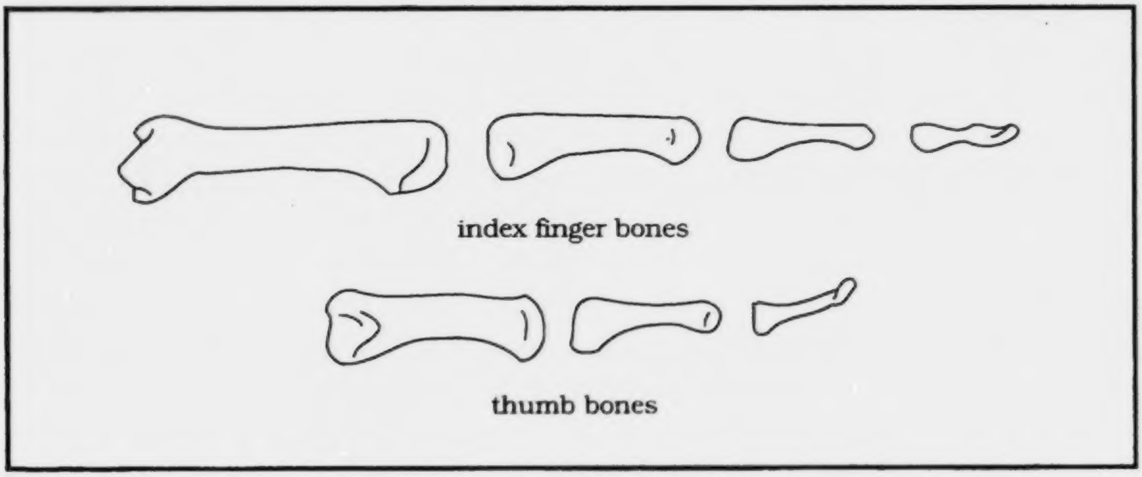
index finger bones
thumb bones

Figure SP 5.8.6(3) Index finger and thumb bones

ACTIVITY 5.8.7
INCLINED PLANES AND SCREWS

OBJECTIVES

The students
- Make an inclined plane.
- Make a low-friction roller.
- Explore to find the least effort needed to pull the roller along an inclined plane at different angles.
- Relate screws, spirals, and propellers to inclined planes.

BACKGROUND

This is part of a series of activities on simple machines. It should follow Activities 5.3.12 BONES, 5.8.3 THE BALANCE, 5.8.4 WHEEL-AND-AXLES, and 5.8.5 LEVERS: WHERE ARE THEY? In INCLINED PLANES AND SCREWS the students explore to find whether it takes more or less effort to pull an object up an inclined plane or to raise it straight up. To get a measure of the effort needed to pull the object, they use their wheel-and-axle systems from Activity 5.8.4 WHEEL-AND-AXLES, string, and modeling clay counterbalances from Activity 5.8.3 THE BALANCE. They then explore ways to make screws, noting any similarities to inclined planes.

Inclined Plane

An *inclined plane* is a machine that reduces the amount of effort that has to be applied to raise an object. It is a ramp. The smaller the angle, the greater the distance that must be traveled to raise an object to a given height. The greater the distance traveled, the less the effort required.

Making an Inclined Plane

An inclined plane can readily be made from cardboard. It should be at least half a meter or a foot and a half long. Help the students get straight pieces of cardboard. The protractor constructed in Activity 5.3.12 BONES can be used to measure angles.

Roller

To focus on the advantages of the inclined plane the students build a roller to be pulled up the plane. A roller reduces friction and provides clearer illustration of the effect of the inclined plane than a block, which will have a tendency to slide less freely over the plane.

A roller can be constructed by drilling a hole in the middle of the bottom and cap of a plastic bottle. A metal coat hanger with its middle cut out can be inserted to act as an axle. See Figure SP 5.8.7(1). The axle should be bent so that the bottle can turn freely.

Roller on the Inclined Plane

To get a sense of how the inclined plane reduces the amount of effort required to raise an object, the students first check to determine the least amount of effort it will take to raise the roller straight up. They can do this by using a counterbalance and a wheel-and-axle system without the inclined plane.

Next the students put the roller on the inclined plane and determine the least amount of effort required to pull it along the plane as the angle is increased and decreased. See Figure 5.8.7(1). They should use the table in Student Page 5.8.7 INCLINED PLANES AND SCREWS to record their data.

The investigation should result in agreement that as the angle becomes smaller, less effort is needed and as the angle becomes greater, more effort is needed. The least amount of effort will be required when the plane is horizontal or nearly so. The greatest amount of effort will be required when the roller is raised straight up.

Friction from the Bottle

The force resisting the free movement of the bottle will be friction produced by the axle, the contact surface of the bottle, and the hanger hook if it slides on the plane. (An interesting side exploration would be to try to reduce the friction.)

Inclined-Plane Mobiles

Spirals, screws, and propellers are also examples of inclined planes. A *screw* is simply an inclined plane twisted into a column. A *propeller* consists of two opposed inclined planes. When they revolve, they push air or water behind or ahead of them.

The students build paper mobiles using spirals and propellers. They then make hypotheses about wind hitting against the surfaces and pushing the mobiles into rotation.

Mathematics

The purpose of this activity is to give the students a general idea of the way inclined planes reduce effort. However, some insightful students may notice a relationship between the effort and distance involved in moving the roller on the inclined plane and the resistance and distance involved in raising the roller straight up. In a system with little friction the product of the length of the plane and the effort to pull the roller along the plane will be equal to the product of the height the roller is raised by the plane and the resistance needed to raise the roller straight up. The mathematical expression looks like this:

$$\text{effort to move object along the plane} \times \text{length of plane} = \text{resistance produced by mass of object} \times \text{height object is raised straight up}$$

STUDENT ROLES

Physicist
Engineer

MATERIALS

plastic soda bottle with hole in cap and bottom
wire coat hanger with middle cut out
cardboard or other hard surface for an inclined plane
string
wheel-and-axle system from Activity 5.8.4 WHEEL-AND-AXLES
counterbalances from Activity 5.8.3 THE BALANCE
protractor from Activity 5.3.12 BONES
Student Page 5.8.7 INCLINED PLANES AND SCREWS

PRODUCTS

Inclined-plane mobiles
Completed Student Pages

PROCEDURES

1. **Help the students make a plastic-bottle roller. See Figure SP 5.8.7(1).**

   Help them
   - Get the roller to move as freely as possible.
   - Center the hook so that when the roller is pulled, it moves in a straight line.
   - Determine the mass of their roller.

2. **Challenge the students by asking what would be the least amount of mass needed to produce enough effort to raise the roller 10 cm straight up using a string and a wheel-and-axle system.**

   Help them
   - Invent a way to hold the wheel-and-axle system so that it raises the roller 10 cm straight up.
   - Experiment to find the least amount of mass needed to produce the effort to lift the roller straight up. (They will usually verify that the mass needed will be a little more than the mass of the roller. This reinforces work done with wheel-and-axles.)
   - Report how they set up their equipment.

3. **Ask the students to determine the least amount of mass that would produce the effort needed to pull the roller 10 cm up the inclined plane at various angles. Sketch a system, giving as little detail as possible.**

   Help the students
   - Invent an inclined plane. (Cardboard can be used, desks can be tilted, and so forth.)
   - Invent a way to measure different angles. (The protractor from Activity 5.3.12 BONES can be used to measure the angles.)
   - Determine the angle that requires the least amount of mass to produce the effort to pull the roller 10 cm.
   - Determine the least amount of mass needed to produce enough effort to pull the roller 10 cm up the inclined plane at 0°, 30°, 45°, and 60°. Have them record their data in the table in Student Page 5.8.7 INCLINED PLANES AND SCREWS.

4. **Review the activity.**

   Ask such questions as these:
   - How are the effort used to move the roller and the mass used to produce the effort related? (Get at the idea that the more mass pulling on the string, the more pull or effort there on the roller. We can therefore use the masses to compare the efforts.)
   - When was the least amount effort used to move the roller 10 cm? (Work for agreement that the least amount of effort was used when the inclined plane was about horizontal or level.)

- When was the greatest amount of effort used to move the roller 10 cm? (Work for agreement that the greatest amount of effort was used when the roller was raised straight up.)
- Looking at your data table, what seems to happen to the amount of effort we have to apply as the plane gets steeper? (Work for the idea that more effort is needed.)
- What happens to the amount of effort we have to apply as the angle of the plane decreases? (Work for the idea that the amount of effort required also decreases.)
- If you have a mountain to climb, would it take less effort to take a trail straight up the side or to go up a long zigzag trail? Why? (Get at the idea that a zigzag trail is like an inclined plane: the less the angle of incline, the less effort it takes to raise our body against gravity.)
- What would be a disadvantage of the zigzag trail? (The zigzag trail would be longer than a straight one.)
- What are the advantages and disadvantages of an inclined plane? (Work to the idea that raising something up an inclined plane requires less effort than raising it straight up, but we must apply the effort over a greater distance.)

5. **Provide a collection of wood screws and bolts for the students to inspect. Then give them a paper inclined plane and ask them to invent a way of making it into a screw. See Figure 5.8.7(2).**

6. **Have the students make inclined-plane mobiles. See Figures 5.8.7(3) and SP 5.8.7(3).**

Help them

- Cut out the shapes in Figure SP 5.8.7(2).
- Invent a way to make an inclined plane out of each set of cutouts.
- Hang the paper inclined planes by thread and watch how they respond to gusts of air. Where necessary, have the students attach paper clips below the mobiles to stabilize them.
- Determine the direction the mobiles turn as the direction of the wind changes.
- Explain how each is an example of an inclined plane.

7. Summarize the activity.

Ask such questions as these:

- What are some examples of inclined planes? (Get at such things as roadways, zigzag uphill trails, stairways, wedges, and carpenter's planes.)
- What are some examples of circular inclined planes? (Get at such things as bolts, nuts, screws, circular stairways, and propellers.)

EXTENSIONS

Have the students

- Add screws and inclined planes to the Scrapbook of Machines. (Wedges, like screws, are special inclined planes. They include knife and ax blades and doorstops. In the study of machines they are sometimes listed separately.)
- Explain how an inclined plane is like a lever. Help the students get at such things as it allows us to use less effort to raise an object.

ILLUSTRATIONS

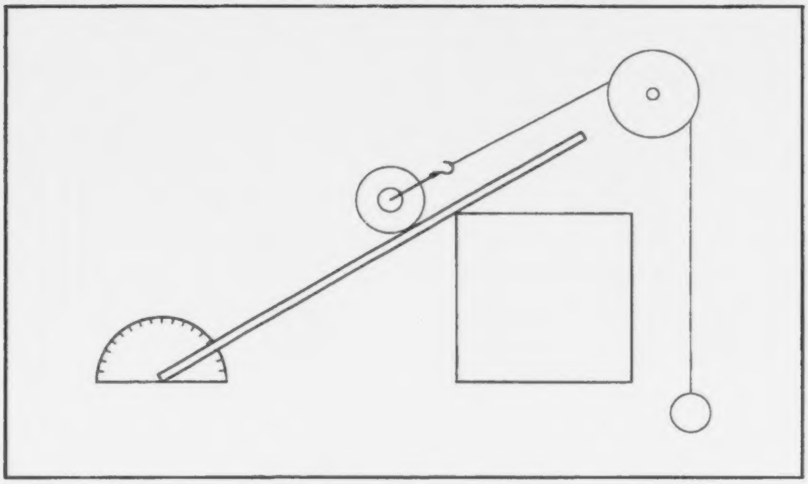

Figure 5.8.7(1) Device for drawing a roller along an inclined plane

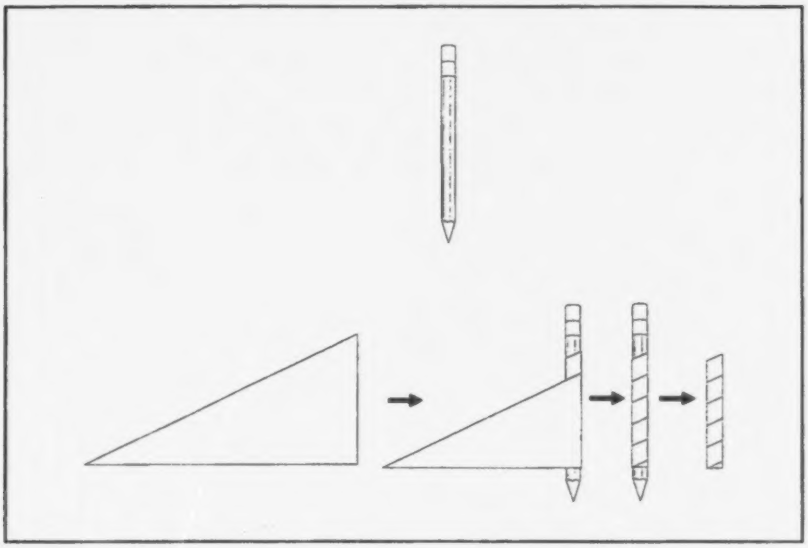

Figure 5.8.7(2) Making a screw from an inclined plane

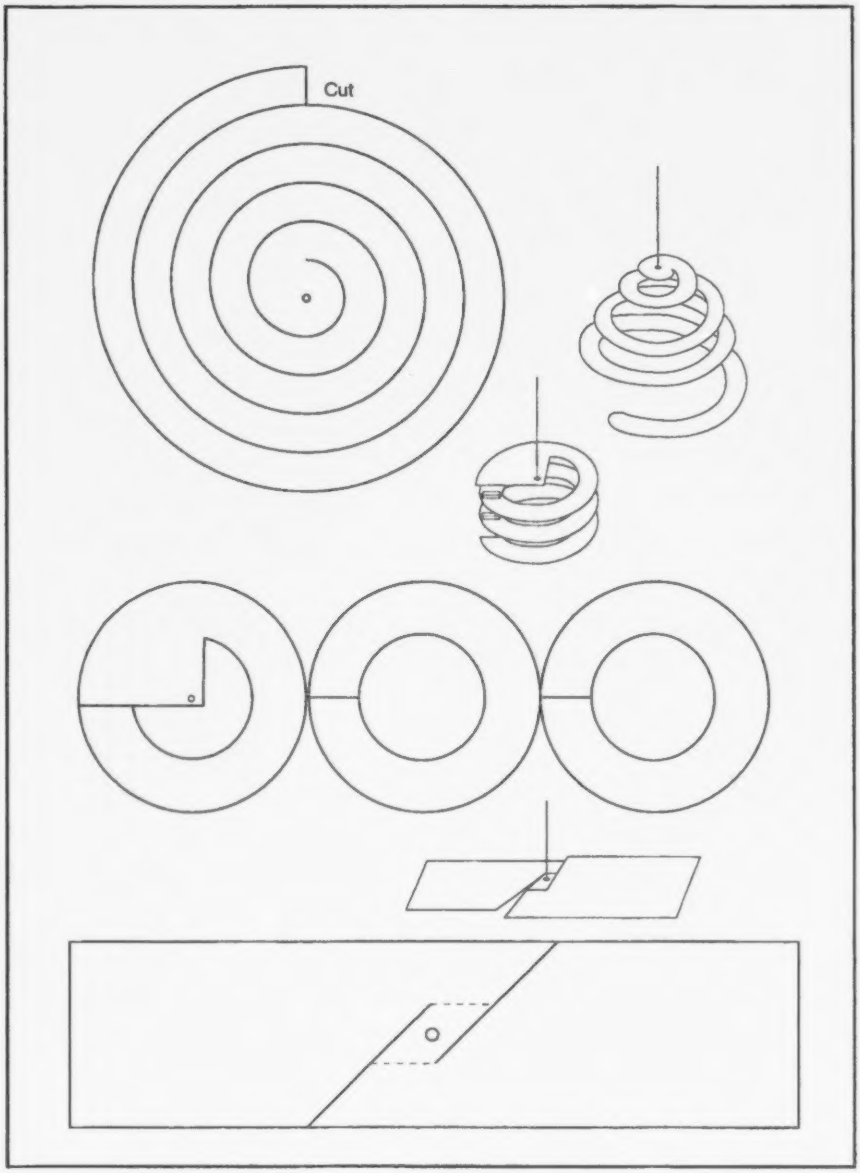

Figure 5.8.7(3) Assembly of inclined-plane mobiles

DASH

Name________________________

Date________________________

STUDENT PAGE 5.8.7 INCLINED PLANES AND SCREWS

1. Construct a roller to use on an inclined plane. See Figure SP 5.8.7(1). Describe how you made the roller and adjusted it so that it could roll freely. Use drawings where needed.

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2. Construct an inclined plane and a wheel-and-axle system to help pull the roller along the plane. Make a drawing of your system.

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Name ______________________________

3. Determine the least amount of mass that produced the effort needed to pull the roller 10 cm up the inclined plane at various angles.

	Least Amount of Mass Needed to Produce the Effort to Pull the Roller up the Inclined Plane
0°	
30°	
45°	
60°	
90°	

4. How does the angle of the inclined plane affect the amount of counterbalance or effort needed to pull the roller up the inclined plane? What is your evidence?

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____

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5. Make a drawing showing how you made an inclined plane into a screw.

Name ______________________________

6. **Cut along the solid lines and make the shapes in Figure SP 5.8.7(2) into mobiles. Suspend the mobiles by thread and stabilize them with paper clips. Explain why these mobiles are inclined planes. Use drawings where needed.**

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ILLUSTRATIONS

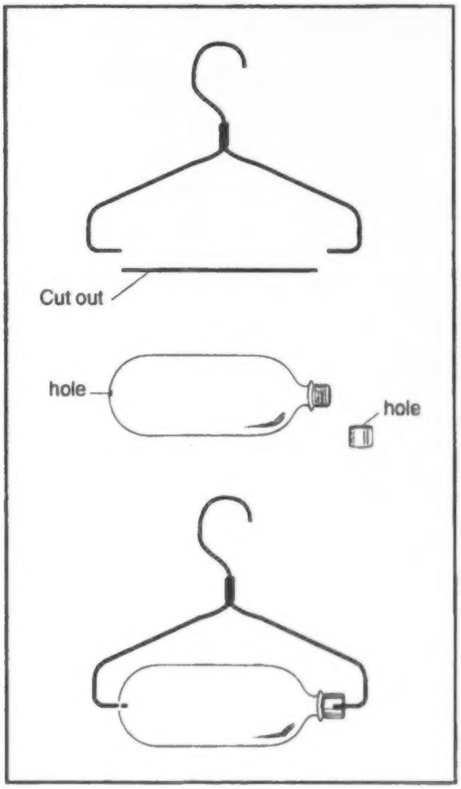

Figure SP 5.8.7(1) Inclined-plane roller

Name ______________________________

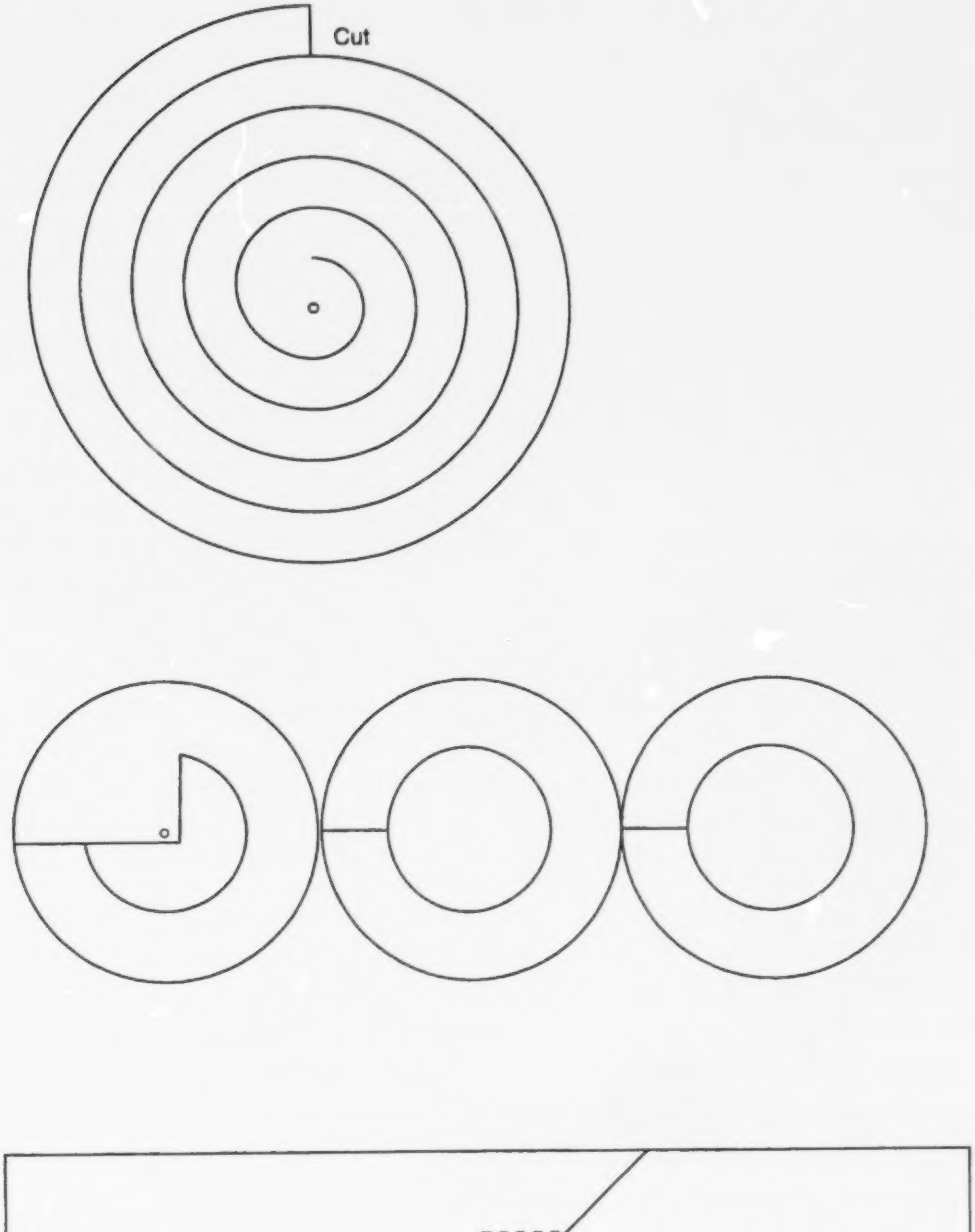

Figure SP 5.8.7(2) Inclined-plane mobiles

ACTIVITY 5.8.8 BLOCK-AND-TACKLE

OBJECTIVES

The students
- Make a block-and-tackle.
- Observe the anomaly that by using a block-and-tackle a single person can pull several people in a test of strength.
- Observe that different counterbalancing masses are needed when varying numbers of supporting strands are used in a block-and-tackle.
- Find that the mechanical advantage of a block-and-tackle is equal to the number of strands supporting the moving block.
- Develop a working definition for mechanical advantage.

BACKGROUND

This is one of a series of activities on simple machines. It should follow Activities 5.8.3 THE BALANCE, 5.8.4 WHEELS AND AXLES, and 5.8.7 INCLINED PLANES AND SCREWS. In BLOCK-AND-TACKLE the students explore the block-and-tackle, an ancient machine probably invented in the Middle East about 8,000 years ago. Today this machine still has countless applications.

Pulleys and Their Use

A pulley is a wheel, usually grooved, that guides a moving rope or line. Figure 5.8.8(1) shows a pulley being used to pull a car. One end of a rope is attached to a strong fixed object, here a tree. A pulley is attached to the car and a rope passes about the pulley. Using this pulley, a person can pull the car with half the effort it would take using only a rope. As seen in the figure the tree supports half of the resistance. It's much like having two people pulling on the rope. Each line or rope supporting a pulley is called a *strand*. In this example there are two strands.

More Pulleys

The amount of effort needed to pull the car can be reduced still more by adding more pulleys. For example, one pulley can be attached to the tree and two to the car. See Figure 5.8.8(2). With the additional pulleys, the car can be pulled with 1/4 the effort needed to pull it with the rope alone. The tree supports 3/4 of the resistance. Four strands of rope are pulling on the car. This is like having four people pulling on the rope.

Block-and-Tackle

When pulleys are held in a frame, they are called a *block*. The students make a primitive form of block using pieces of plastic pipe in a ruler frame. The smooth, rounded surfaces of the pipe function as wheels. A set of two blocks and a rope or line is called a *block-and-tackle*.

Effort

We can estimate the amount of effort it will take to lift or pull an object using a block-and-tackle. We divide the force of resistance being pulled by a pulley or block of pulleys by the number of supporting strands of rope doing the pulling. In Figure 5.8.8(1) the pulley attached to the car is pulled by two strands of rope—one attached to the tree, the other pulled by the person. Half as much effort is required when the pulley is used.

In Figure 5.8.8(2) there are four strands of rope attached to the block of pulleys on the car. When the resistance is divided equally among the four strands, each strand bears 1/4 of the resistance.

Making Blocks

A simple set of blocks can be made from drilled boards or wooden or plastic rulers and pieces of plastic pipe bolted together. See Figure 5.8.8(3). If possible have the students use rulers that already have three holes. Using these rulers they can quickly assemble a block. However, for the contest stronger blocks are needed, and these can be made using drilled pieces of wood.

The Contest

A contest is held in which two classmates are pitted against one. The two students pulling together can be a *little* stronger than the third pulling alone. The third member uses a block-and-tackle to pull the two. Before setting up the contest, test the blocks to make sure they will not break.

Threading the Contest Blocks

The contest blocks can be threaded in several different ways. The students will later explore to discover this. Figure 5.8.8(4) shows a way of threading of rope for the contest so that four strands of rope support the movable block. Note that one block, the "immovable block," is tied to a tree or other fixed object with a length of rope. The two students producing the resistance pull on another length of rope tied to the other block—the "movable block." The rope pulled on by the single student producing the effort is tied to the immovable block and is threaded through both blocks.

After the contest, demonstrate that the movable block can easily be pulled by the two students. Then have the third student pull on the threaded rope. Using this system, a 100-pound student should be able to pull two 120-pound students with ease.

Mechanical Advantage

Mechanical advantage refers to the number of times the effort exerted is increased by a machine. Ideally, the mechanical advantage of a block-and-tackle will be equal to the number of strands supporting or pulling the block attached to the object being moved. In Figure 5.8.8(2) the moving block with its mass is supported by four strands of rope, giving a mechanical advantage of 4. In the practical world of friction the mechanical advantage will be a bit less than the ideal 4.

Calculating Mechanical Advantage

The students are given the definition that mechanical advantage is the amount that a machine multiplies effort. If we know the amount of effort we can exert and the mechanical advantage of a machine, we can calculate the amount of resistance we can move by using the formula

$$\text{Resistance} = \text{Effort} \times \text{Mechanical Advantage}$$

However, we normally measure the effort and the resistance and then calculate the mechanical advantage by using the formula

$$\text{Mechanical Advantage} = \text{Resistance} \div \text{Effort}.$$

Mechanical Advantage and Other Machines

Mechanical advantage is also a term appropriate to use with levers, wheel-and-axle systems, and inclined planes. For example, if a lever or wheel-and-axle system that allows an effort produced by a 10-g mass to counterbalance a resistance produced by a 20-g mass, the mechanical advantage is 2. The effort is doubled by the machine. If the effort produced by a 20-g mass counterbalances a resistance produced by a 60-g mass, the mechanical advantage is 3.

Using Wheels as Pulleys

It is recommended that the students use the wheels from Activity 5.8.4 WHEEL-AND-AXLES as pulleys for their investigations. To make a block with two sets of wheels on the same axle they will need two sets of wheels that can turn independently. This kind of block is different from the ruler-block in that the wheels are next to each other. Be sure the students thread only one of the wheels on each set.

Friction

Friction is a force that resists motion. It reduces a machine's efficiency or how well it works compared to ideal performance. Block-and-tackles normally produce a fairly large amount of friction. The diagrams used in this activity show ideal systems without friction. However, because several supporting strands of line have been passed about the blocks, friction will increase and the machines will become less and less efficient.

To get the clearest experimental results, generalize after getting data from using two, three, and four supporting strands. Then talk about friction. Have the students suggest how friction might prevent the system from giving ideal results.

STUDENT ROLES

Physicist
Engineer

MATERIALS

CONTEST

two wooden frame pieces drilled with three 3/16-in diameter holes to fit 1/8-in bolts (Drill bolt holes in both frame pieces so they are centered, in a straight line, about equal distances apart, and directly opposite each other. You will need 2 frame pieces per block. Construct 2 contest blocks.)
pieces of 1/2-in plastic pipe, 1/2 in long, 3 pieces per block (Sand the cut ends of the pipe to remove burs.)
1/8-in bolts, 2-1/2 to 3 in long, with wing nuts and washers, 3 sets per block
smooth clothesline or nylon rope, at least 36 ft (12 m) long, 400-pound test (Cut two lengths of rope 6 to 9 ft [2 to 3 m] long. Tie one to the movable and one to the fixed block. Tie and thread the remainder through the blocks. Test for strength and to be sure that the rope moves freely. See Figure 5.8.8 [4].)
coarse sandpaper

INVESTIGATION

3-holed plastic or wooden rulers, 2 rulers per ruler-block, 1 block per student group.

pieces of 1/2-in plastic pipe, 1/2 in long, 3 pieces per ruler-block (Sand the cut ends of the pieces to remove burs.)

1/8-in bolts, 2-1/2 to 3 in long, with wing nuts and washers, 3 per ruler-block

nylon string, 7-1/2 to 9 ft (2-1/2 to 3 m) per ruler-block

coarse sandpaper

modeling clay for counterbalances

wheel-and-axle systems from Activity 5.8.4 WHEEL-AND-AXLES

balances and clay counterbalances from Activity 5.8.3 THE BALANCE

Student Pages 5.8.8 BLOCK-AND-TACKLE

PRODUCTS

Completed Student Pages
Block-and-tackles

PROCEDURES

1. **Show the students the block-and-tackle and tell them it will be used in a tug-of-war contest between a single student and two classmates.**

   Point out where it is secured to a fixed object, which block is the "immovable block," which block is the "movable block," and the two ropes that will be pulled in the contest. See Figure 5.8.8(4).

2. **Set up the contest so that two students are pulling against one student. The single student pulls the rope threaded through the block-and-tackle, trying to pull the opposing pair toward him or her by pulling the blocks together. The two students using the rope attached to the movable block try to pull the single student toward them by pulling the blocks apart.**

3. **Hold the contest and have the students explore the block-and-tackle.**

   Ask such questions as
   - Who won the contest?

- How can this be? (Take all suggestions. Have the students test to see that the pair of students can pull the blocks apart as easily as the single student can pull them together.)

4. **Help the students make blocks from rulers and pipe.**

5. **Instruct the students how to make a different kind of block using two sets of wheels on the same axle. See Figure 5.8.8(7).**

   Help them
   - Put two sets of wheels on a single axle with washers between them so that the wheels do not bind on each other. (Washers can be made of cardboard.)
   - Attach a string to the axle between the two sets of wheels.
   - Securely support the system so that a ruler-block can be suspended below the wheeled block.

6. **Have the students invent a way to determine the mass of their ruler-block. Have them record the mass in Student Page 5.8.8 BLOCK-AND-TACKLE.**

7. **Help the students thread their blocks with string to carry out the investigations below. Have them record the number of strands supporting the ruler-block, the amount of the mass producing the resistance (the mass of the ruler-block), and the mass used to counterbalance the ruler-block (the mass producing the effort). Have them make a diagram showing the way the blocks are threaded.**

   - *Investigation A:* Find the counterbalancing mass when the lower block is supported by one strand of line. See Figure 5.8.8(5).
   - *Investigation B* Find the counterbalancing mass when the lower block is supported by two strands of line. See Figure 5.8.8(6).
   - *Investigation C:* Find the counterbalancing mass when the lower block is supported by three strands. See Figure 5.8.8(7).
   - *Investigation D:* Find the counterbalancing mass when the lower block is supported by four strands. See Figure 5.8.8(8).

8. Summarize the work on block-and-tackles.

Ask such questions as these:

- How did you measure the mass of the ruler-block? (The students may not be able to weigh the ruler-block directly on their balance. If its mass exceeded the masses of the counterbalances used for weighting, they can pass a string over one wheel and make a large clay counterbalance equal to the mass of the ruler-block. See Figure 5.8.8[5]. This clay counterbalance can then be split into pieces small enough to be weighed on their balance. The total mass can be determined by adding the masses of the pieces.)
- What was the a mass of the counterbalance when one strand supported the block? (Work for agreement that it was the same or about the same as the mass of the ruler-block. See Figure 5.8.8[5].)
- How was the upper block supported? (Work for agreement that the upper block was supported by the surface on which the axle rested.)
- What was the approximate mass of the counterbalance when two strands supported the block? (Work for agreement that it was about half as much as it was when one strand held the block. See Figure 5.8.8[6].)
- What was the approximate mass of the counterbalance when three strands supported the block? (Work for agreement that it was about 1/3 as much as it was when one strand held the block. See Figure 5.8.8[7].)
- What was the approximate mass of the counterbalance when four strands supported the block? (Work for agreement that it was about 1/4 as much as it was when one strand held the block. See Figure 5.8.8[8].)
- What generalization can we make about estimating the counter-balancing effort from the way we thread a block? (Work for agreement that we can get an estimate the amount of mass producing the effort needed to lift or pull an object by dividing the mass producing the resistance by the number of supporting strands of string or line about the moving block.)

9. Introduce the term mechanical advantage. *Mechanical advantage* refers to the number of times the effort is multiplied by a machine. We can calculate it by dividing the resistance by the effort needed to move the resistance.

10. **Have the students determine the mechanical advantage of the block-and-tackles in Procedure 7, Investigations A–D. (The mechanical advantage is 1 in Investigation A, 2 in Investigation B, 3 in Investigation C, and 4 in Investigation D.)**

    Ask such questions as these:
    - How did you find mechanical advantage? (Work for the idea of dividing the resistance by the effort.)
    - Why was the mechanical advantage 1 when a ruler-block was supported by one strand of string? (Work for the idea that the resistance and effort were the same. When a number is divided into itself, the quotient is 1.)
    - How does the number of strands supporting the ruler-block seem to relate to the mechanical advantage? (Work for the observation that the numbers are quite close to each other. Point out that in the ideal block-and-tackle the number of strands supporting the ruler-block would equal the mechanical advantage.)
    - What might prevent our blocks from giving us ideal mechanical advantage? (Work for the idea of friction produced by surfaces rubbing over each other.)
    - How might friction operate in the other machines we have worked with? (Review the machines and get at the idea that friction might have prevented them from working exactly as we would have predicted. The presence of friction would require that more effort be used.)

EXTENSIONS

- Help the students make a list of places and situations where a block-and-tackle is used.
- Introduce the idea that we can calculate the mechanical advantage of any machine by using the following formula:
  Mechanical Advantage = Resistance ÷ Effort
- To review machines, post a mechanical advantage question every day or so for reflection.

EXAMPLE

On a first-class lever a resistance produced by a 10-kg mass is placed 0.5 m from the fulcrum. A 2-kg mass counterbalances it.
- How far is the effort from the fulcrum? (2.5 m)
- What is the mechanical advantage of the machine? (5)
- Draw such a system.

EXAMPLE

An inclined plane is 3 m long. A 12-kg ball is lifted 1 m off the ground as it is pulled up the plane by an effort produced by a 4-kg counterbalance.

- What mass is producing the resistance? (12 kg)
- What is the mechanical advantage? (3)
- Draw such a system.

ILLUSTRATIONS

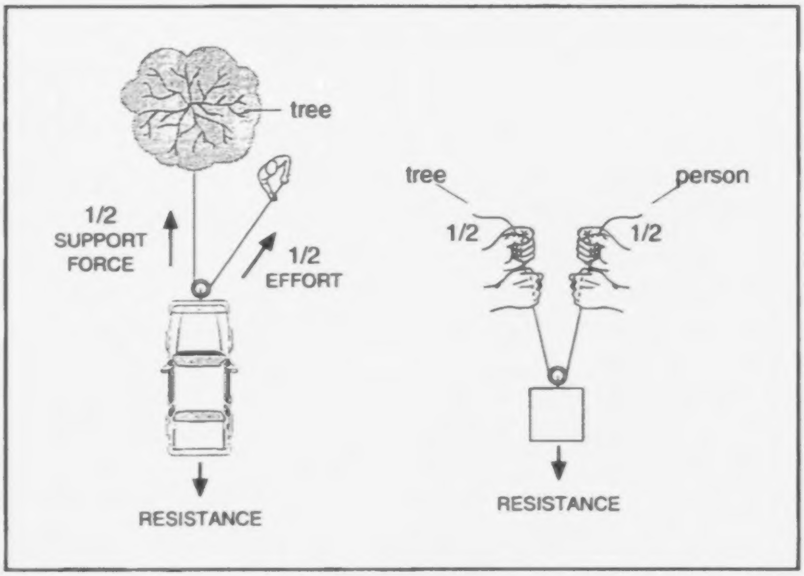
tree
1/2 SUPPORT FORCE
1/2 EFFORT
RESISTANCE
tree
person
1/2
1/2
RESISTANCE

Figure 5.8.8(1) A single pulley reduces the effort needed to pull a car by 1/2. The resistance of the car is supported by 2 strands of rope. The effort exerted on the car is twice the effort exerted by the person. The mechanical advantage is 2.

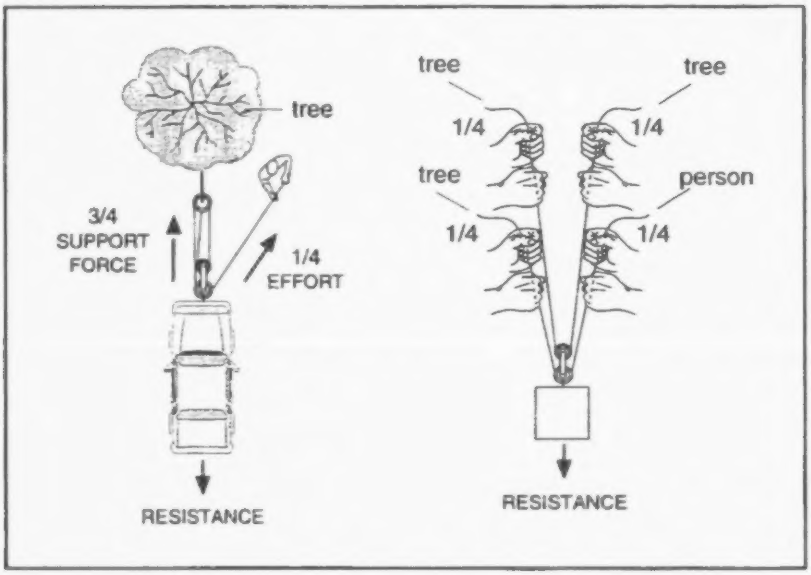
tree
3/4
SUPPORT
FORCE
1/4
EFFORT
RESISTANCE
tree
tree
1/4
1/4
tree
person
1/4
1/4
RESISTANCE

Figure 5.8.8(2) The 3 pulley wheels, 2 on the car and 1 on the tree, reduce the effort needed to move the car. There are 4 strands of rope supporting the car. The effort exerted on the car is 4 times the effort exerted by the person. The mechanical advantage is 4.

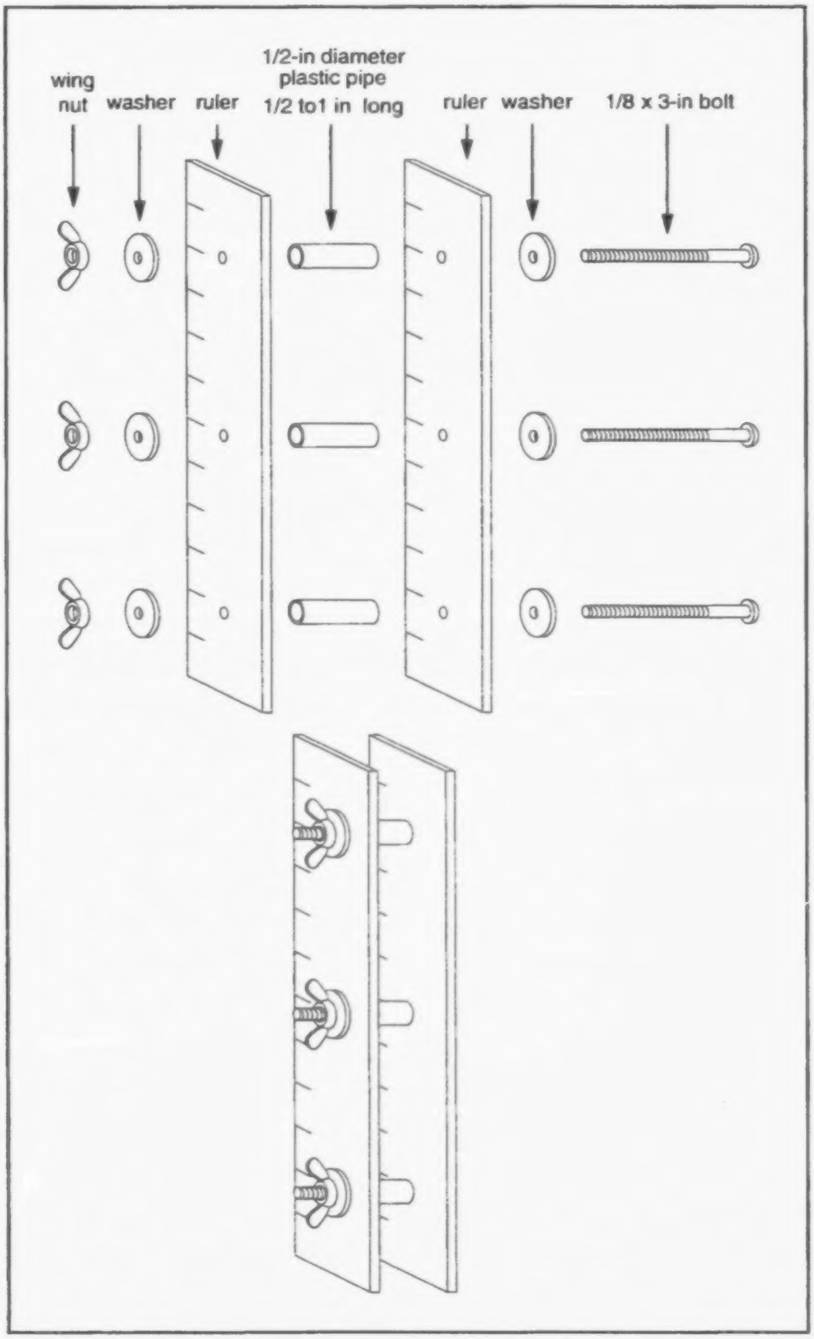
wing nut
washer
ruler
1/2-in diameter plastic pipe 1/2 to1 in long
ruler
washer
1/8 x 3-in bolt

Figure 5.8.8(3) Making a block using bolts, wing nuts, washers, plastic pipe, and plastic or wooden rulers as a frame. For extra strength drilled pieces of wood should be used as the frame for contest blocks instead of rulers.

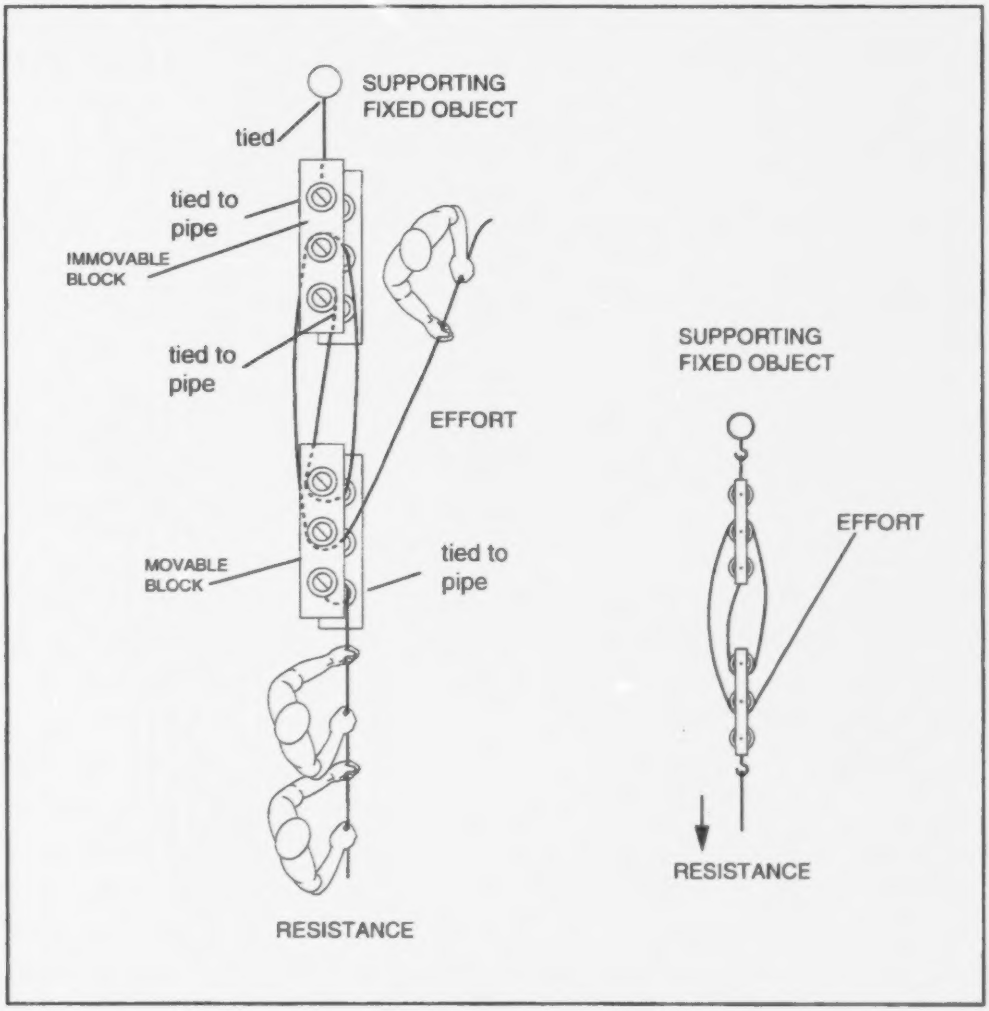
SUPPORTING
FIXED OBJECT
tied
tied to
pipe
IMMOVABLE
BLOCK
tied to
pipe
EFFORT
MOVABLE
BLOCK
tied to
pipe
RESISTANCE
SUPPORTING
FIXED OBJECT
EFFORT
RESISTANCE

Figure 5.8.8(4) Threading the blocks of a block-and-tackle so that a lighter student can pull two heavier students. Four strands of rope support the lower block. The mechanical advantage is 4.

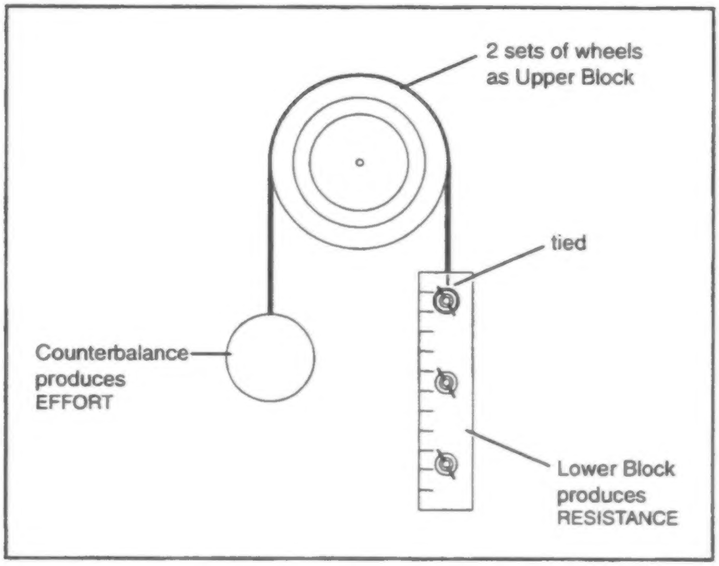
2 sets of wheels as Upper Block
tied
Counterbalance produces EFFORT
Lower Block produces RESISTANCE

Figure 5.8.8(5) The effort produced by the counterbalance equals the lower block's resistance. One strand of line supports the lower block. The mechanical advantage is 1.

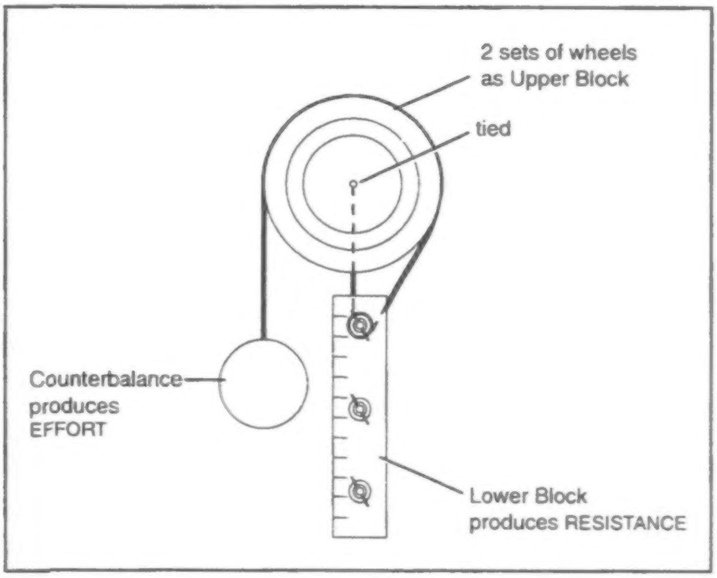
2 sets of wheels as Upper Block
tied
Counterbalance produces EFFORT
Lower Block produces RESISTANCE

Figure 5.8.8(6) The effort produced by the counterbalance is equal to 1/2 the lower block's resistance. Wheels are used for the upper block. Two strands of line support the lower block. The ends of the line are tied to the axle and the counterbalance. The mechanical advantage is 2.

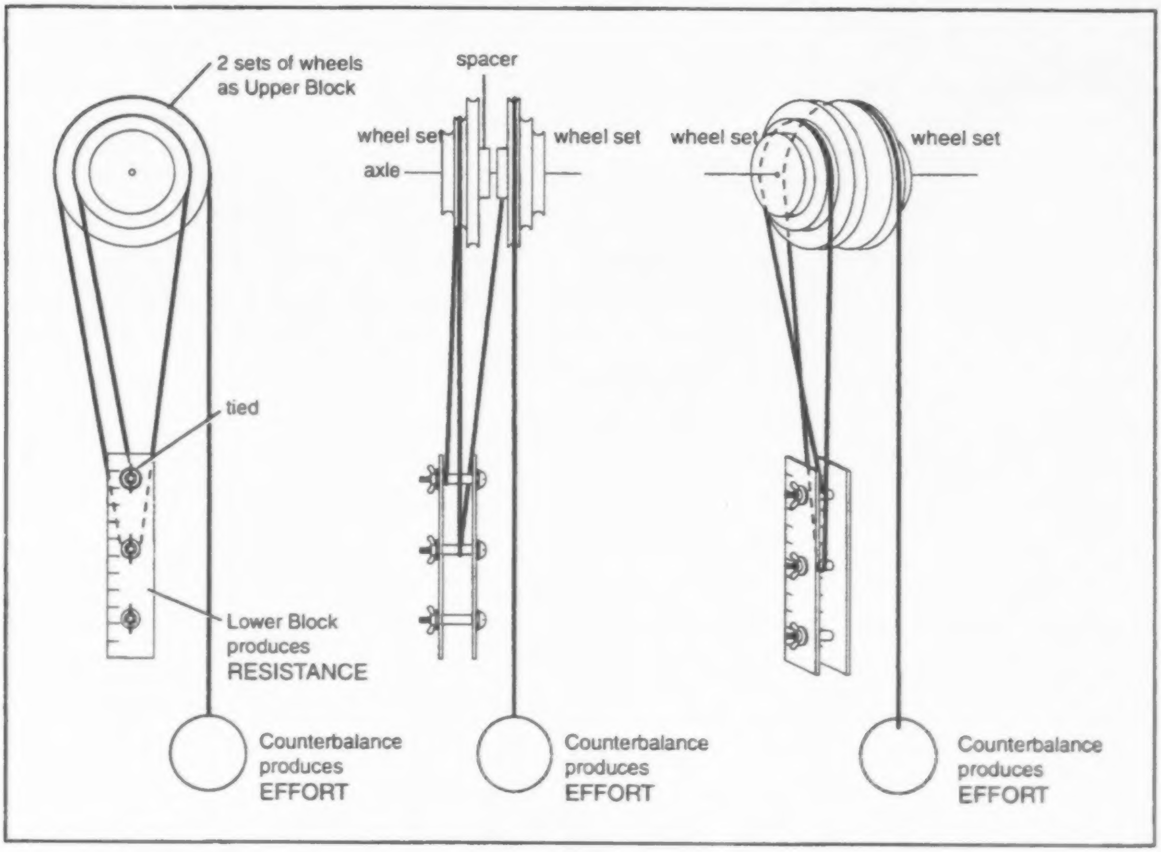
2 sets of wheels as Upper Block
spacer
wheel set
wheel set
axle
wheel set
wheel set
tied
Lower Block produces RESISTANCE
Counterbalance produces EFFORT
Counterbalance produces EFFORT
Counterbalance produces EFFORT

Figure 5.8.8(7) Three views of the same setup. Ideally the effort produced by the counterbalance is equal to 1/3 the lower block's resistance. Two separate sets of wheels are used to make the upper block. The ends of the line are tied to the lower block and the counterbalance. Three strands of line support the lower block. The mechanical advantage is 3.

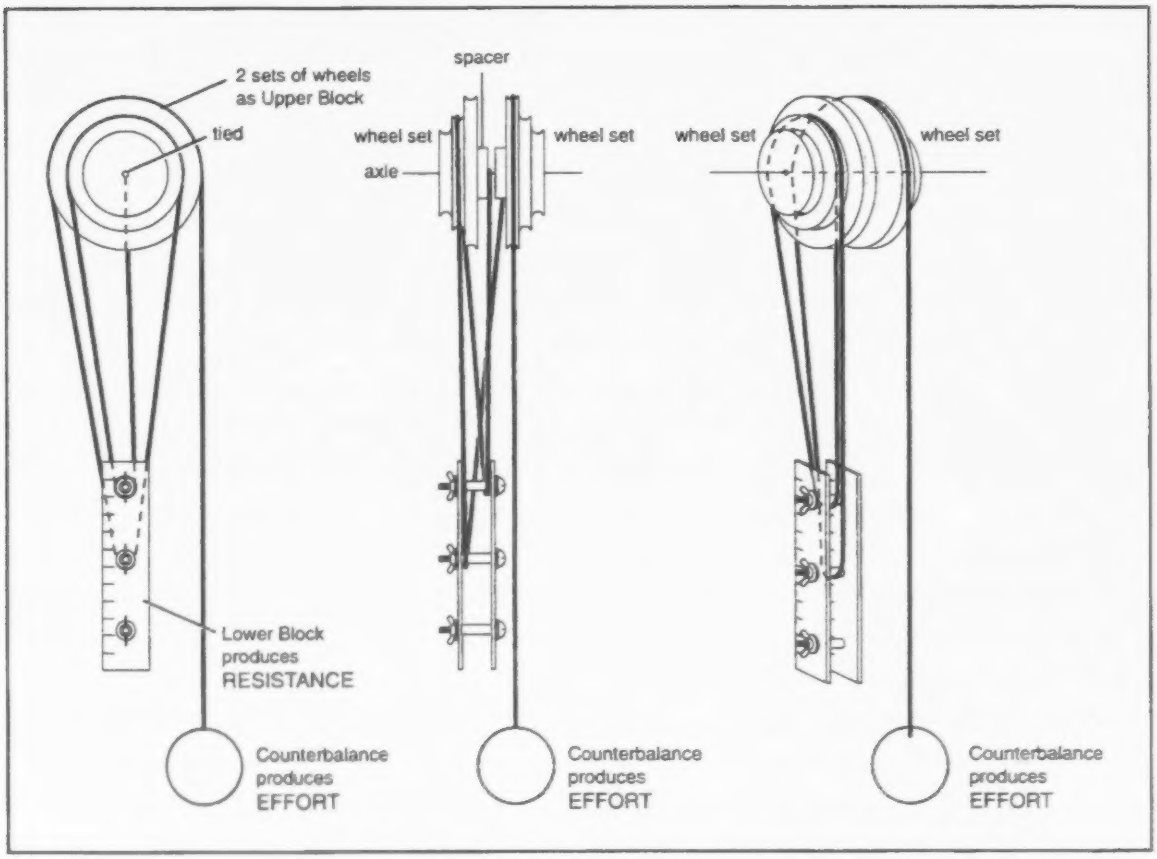
2 sets of wheels as Upper Block
tied
spacer
wheel set
wheel set
axle
wheel set
wheel set
Lower Block produces RESISTANCE
Counterbalance produces EFFORT
Counterbalance produces EFFORT
Counterbalance produces EFFORT

Figure 5.8.8(8) Three views of the same setup. Ideally the effort produced by the counterbalance is equal to 1/4 the lower block's resistance. Two separate sets of wheels are used to make the upper block. Four strands of line support the lower block. The ends of the line are tied to the axle and the counterbalance. The mechanical advantage is 4.

DASH

Name____________________________

Date____________________________

STUDENT PAGE 5.8.8 BLOCK-AND-TACKLE

1. Draw a block-and-tackle that allows one student to pull two other students.

2. Record the mass of the ruler-block and explain how you determined it.

Mass of the ruler-block __________

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Name ______________________________

3. Use two separate sets of wheels as an upper block and a ruler-block as a lower block. The lower block produces the resistance. Use clay counterbalances to produce the effort in the following Investigations.

Investigation A. Determine the mass that counterbalances the lower block when the lower block is supported by one strand of string. Draw your system. Record the information called for in 1–3 below.

1.	Number of supporting strands	
2.	Mass producing resistance	
3.	Mass producing effort	
4.	Mechanical advantage	

Investigation B. Determine the mass that counterbalances the lower block when the lower block is supported by two strands of string. Draw your system. Record the information called for in 1–3 below.

1.	Number of supporting strands	
2.	Mass producing resistance	
3.	Mass producing effort	
4.	Mechanical advantage	

Name ______________________________

Investigation C. Determine the mass that counterbalances the lower block when the lower block is supported by three strands of string. Draw your system. Record the information called for in 1–3 below.

1.	Number of supporting strands	
2.	Mass producing resistance	
3.	Mass producing effort	
4.	Mechanical advantage	

Investigation D. Determine the mass that counterbalances the lower block when the lower block is supported by four strands of string. Draw your system. Record the information called for in 1–3 below.

1.	Number of supporting strands	
2.	Mass producing resistance	
3.	Mass producing effort	
4.	Mechanical advantage	

Name ____________________

4. Explain how we can estimate the mass producing the counterbalancing effort when using a block-and-tackle if we know the number of strands supporting the lower block.

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5. Record your working definition of mechanical advantage. Explain how you can find the mechanical advantage of a block-and-tackle.

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6. Determine the mechanical advantage of the block-and-tackles in Item 3, Investigations A–D. Record the mechanical advantage with the other data.

7. Explain how friction might affect the mechanical advantage of machines?

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ACTIVITY 5.8.9 FORCES PROJECT

OBJECTIVES

The students

- Design "Rube Goldberg" devices to incorporate the machines they have previously explored.
- Test their devices.
- Develop sales pitches to sell their devices

BACKGROUND

This activity, the culmination of the forces and machine series, should be preceded by Activities 5.8.1–5.8.8. FORCES PROJECT is designed to allow the students to demonstrate their understanding of machines by solving an engineering problem. They are asked to build a "Rube Goldberg" device that will perform a simple task such as

- breaking an egg
- turning off a light
- crushing a can
- closing a lunch box
- watering a plant
- any other simple task

The students are to build their device out of simple machines that should include at least one

- lever
- inclined plane
- screw
- wheel-and-axle system
- block-and-tackle system

They should attempt to put as many different examples of machines in their device as they can.

Demonstration

A festive contest environment will enhance the activity. A test of the devices at the end of school gives a dramatic ending to the year's work.

STUDENT ROLE

Engineer

MATERIALS

as required by students
Student Page 5.8.9 FORCES PROJECTS

PRODUCTS

Completed Student Pages

PROCEDURES

1. **Set out the rules for the forces projects.**

   Have the students
   - Agree on an engineering task (breaking an egg, crushing a can, and so forth).
   - Work in small groups.
   - Use as many different machines as possible.
   - Make a system that actually works.
   - Demonstrate their device.
   - Make a diagram of their device.

2. **Help the students demonstrate their devices and make sales pitches for their effectiveness in carrying out the tasks they were engineered to do.**

   Help them
   - Identify each of the machines used.
   - Identify the class of any levers.
   - Give a count of the total number of machines.

EXTENSION

- Have the students share their devices with other classes.

DASH

Name____________________________

Date____________________________

STUDENT PAGE 5.8.9 FORCES PROJECT

1. Describe what the device is intended to do.

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2. Draw your device and label each machine in it.

3. Develop a sales pitch to sell your device as the best device to do the assigned task.

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DASH

Name________________________

Date________________________

STUDENT PAGE 5.8.1 PUSHES, PULLS, AND FORCES

1. Record your working definition of a force.

2. Give examples of each of the following:
   - A *pull* operating against a *pull* without movement.
   - A *push* operating against a *push* without movement.
   - A pull operating against a *pull* with movement.
   - A push operating against a *push* with movement.

3. Make two force-measuring instruments. See Figure 5.8.1. Describe how you standardized your instruments to measure the force produced by 20 and 40 mL water. Call these measurements 20 and 40 *units of force* or just *units.*

Name ________________________________

4. Describe how you used your instruments to measure 40 units of force pulling straight down, up, and sideways. Use drawings as needed.

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5. Connect the instruments as shown in Figure SP 5.8.1. Use your finger to hold the paper-clip hooks attached to the string so they do not move when the rubber bands are stretched. Record your predictions about the hooks' movement when they are released. Test and record what actually happens.

Two rubber bands are stretched so that 20 units of force oppose 20 units of force.

PREDICTED MOVEMENT ________________________________

ACTUAL MOVEMENT ________________________________

Two rubber bands are stretched so that 40 units of force oppose 40 units of force.

PREDICTED MOVEMENT ________________________________

ACTUAL MOVEMENT ________________________________

Two rubber bands are stretched so that 40 units of force oppose 20 units of force.

PREDICTED MOVEMENT ________________________________

ACTUAL MOVEMENT ________________________________

Name ______________________

6. Describe what opposing forces are like when movement takes place and when it doesn't.

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7. Describe your own investigations with force-measuring instruments.

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ILLUSTRATION

Name ______________________________

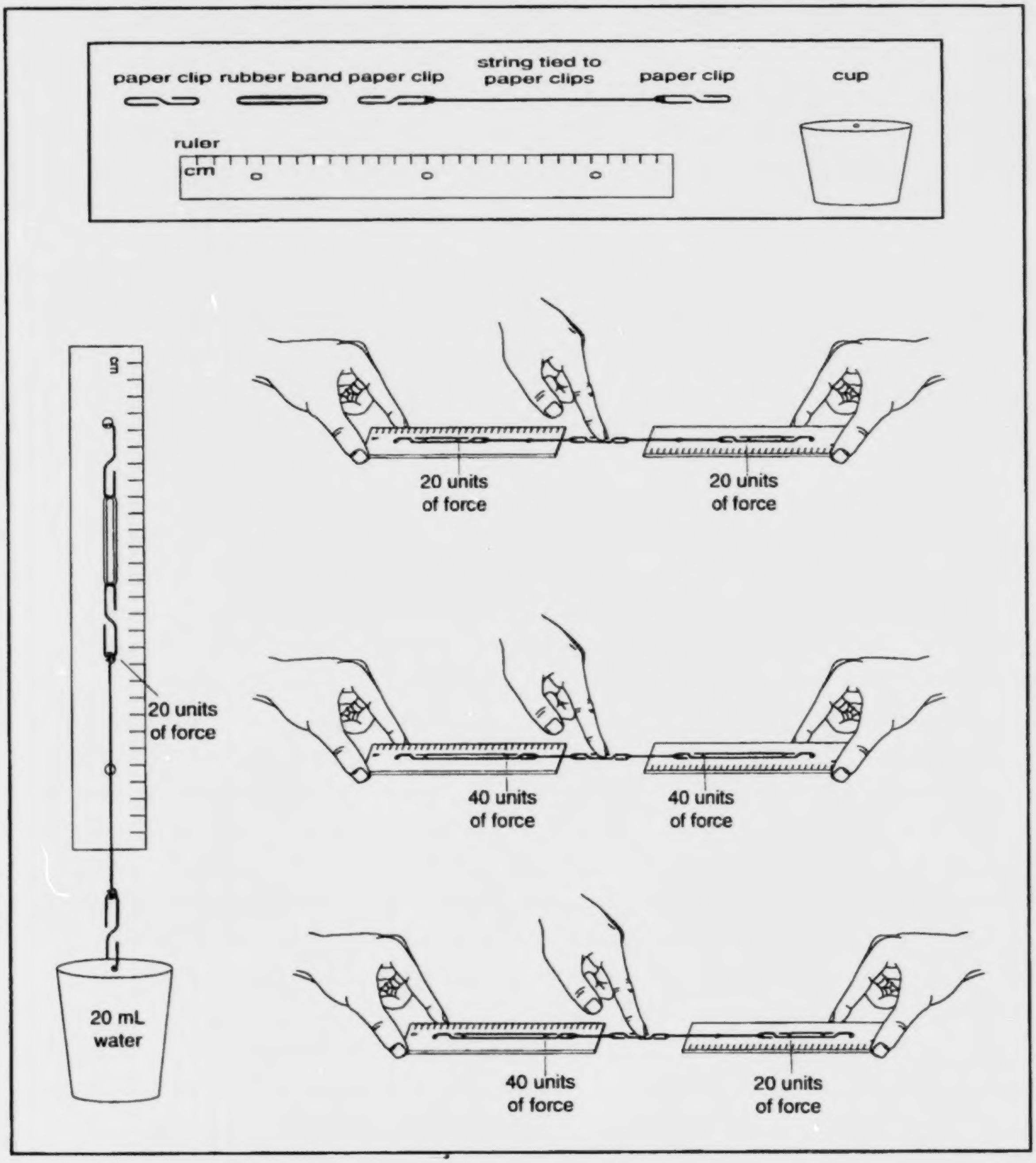
paper clip
rubber band
paper clip
string tied to paper clips
paper clip
cup
ruler
cm
cm
20 units of force
20 mL water
20 units of force
20 units of force
40 units of force
40 units of force
40 units of force
20 units of force

Figure SP 5.8.1 Parts for a force-measuring instrument, assembly and standardization of the instrument, and arrangement of two instruments for investigating interacting forces. Force is measured as the amount of stretch of the rubber band.

DASH

Name________________________

Date________________________

STUDENT PAGE 5.8.2 TEETER-TOTTERS

1. Draw your teeter-totter and explain how it works.

Name ______________________________

2. Use the table below to record your data.

Table SP 5.8.2 Teeter-totter data

Number of paper clips on left side	Distance from fulcrum on left side	Number of paper clips on right side	Distance from fulcrum on right side

3. Describe how a child and a parent can adjust their positions on a teeter-totter to keep balance.

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Name ______________________________

4. **Make a quantitative generalization about teeter-totters. Describe how paper clips and distances can be adjusted to keep balance.**

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Name__________________________

Date__________________________

DASH

STUDENT PAGE 5.8.3A METRIC MASS MEASUREMENT

THE METRIC SYSTEM AND MASS MEASUREMENT

Mass

The *mass* of a thing is a measure of the amount of matter in it. *Matter* is anything that we can feel. Matter includes all solids, liquids, and gases. We measure mass on a balance. Common units of mass in the metric system are the *gram* and the *kilogram*. One kilogram is 1,000 grams.

History of Mass Units

The French creators of the metric system built the metric mass units around metric volume. A gram was defined as the mass of 1 cubic centimeter of water, measured at 4°C. Fortunately, the mass of 1 cubic centimeter or milliliter of liquid water remains about 1 gram from 0°C to well above room temperature.

The U.S. System of Measurement

The U.S. pound (lb) was standardized with the kilogram in 1893. There are 16 ounces (oz) in a pound, and 454 grams (g) of matter have the same weight as a pound.

METRIC AND U.S. UNITS OF MASS

1 kilogram (kg) = 2.20 pounds (lb)
1 pound (lb) = 0.45 kilograms (kg)
1 pound (lb) = 454.00 grams (g)
1 ounce (oz) = 28.40 grams (g)

DASH

Name____________________________

Date_____________________________

STUDENT PAGE 5.8.3B THE BALANCE

1. Define mass.

2. Draw your balance and explain how it works.

Name_______________________

Date_______________________

DASH

STUDENT PAGE 5.8.4 WHEEL-AND-AXLES

1. Make a multiple wheel-and-axle system out of cardboard wheels. See Figure SP 5.8.4(1). Use a nail to make a groove in the rim of each wheel. Use the drilled holes to center the wheels and rims and then glue them together.

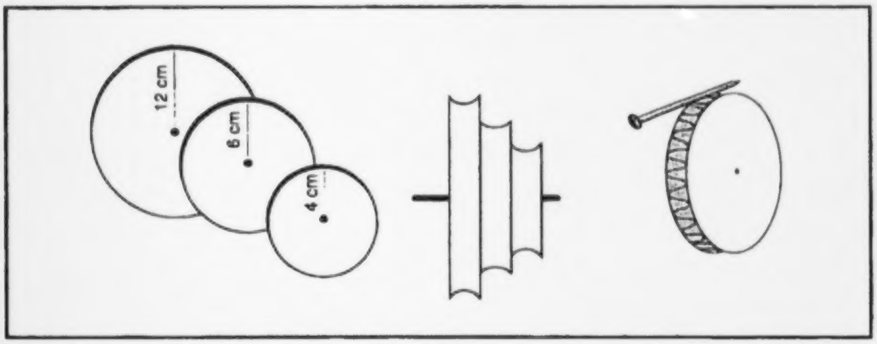

Figure SP 5.8.4(1) Making a wheel-and-axle system

2. Suspend the system so you can add string and counterbalances easily. Draw your system and describe how you suspended it.

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Name ____________________________

3. Problem A: Secure a string on the rim of the 24-cm wheel. Wrap the string around the rim and suspend a 20-g counterbalance from one side. Predict the mass of a counterbalance on the other side that will keep the wheel system from turning. See Figure SP 5.8.4(2). Test the system.

Predicted mass of counterbalance __________

Actual mass of counterbalance __________

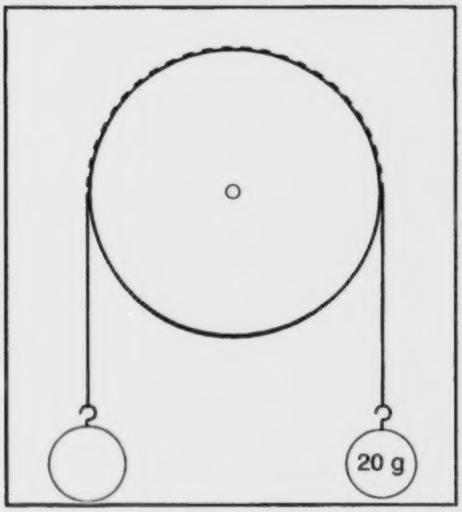

Figure SP 5.8.4(2)
Problem A Showing only the outer wheel

4. How is this wheel-and-axle system like a teeter-totter system? Draw a similar teeter-totter system and describe the similarities.

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____

Name ______________________

5. Problem B: Secure a string on the rim of the 24-cm wheel. Wrap the string around the rim and suspend a 20-g counterbalance from one side. Secure another string to the rim of the 12-cm wheel and wrap it around the rim. Predict the mass of a counterbalance needed to keep the wheel system from turning. See Figure SP 5.8.4.(3). Test the system.

Predicted mass of counterbalance ______________

Actual mass of counterbalance ______________

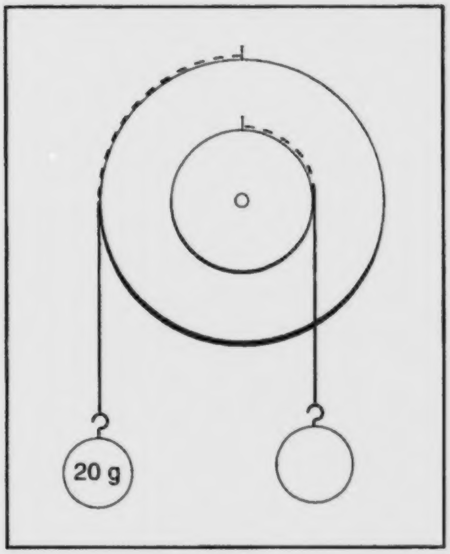

Figure SP 5.8.4(3) Problem B
Showing only the outer and middle wheels

6. How is this wheel-and-axle like a teeter-totter system? Draw a similar teeter-totter system and describe the similarities.

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Name ______________________________

7. **Problem C**: Secure a string on the rim of the 24-cm wheel. Wrap the string twice around the wheel so that it hangs down about 20 cm below the wheel on both sides. Attach a 20-g counterbalance to one end and a 10-g counterbalance to the other. See Figure SP 5.8.4(4). Record what you predict will happen when the two counterbalances are released. Test the system.

Prediction ______________________________

Actual events ______________________________

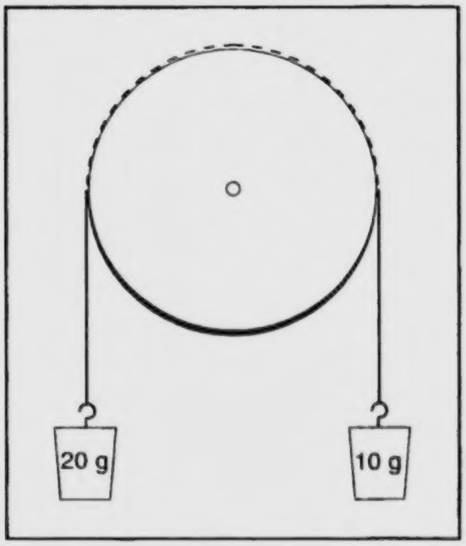

Figure SP 5.8.4(4)
Problem C Showing only the outer wheel

8. **Explain how the system operated.**

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Name ______________________________

9. **Problem D**: Secure a string on the rim of the 24-cm wheel. Wrap the string twice around the wheel and attach a 20-g counterbalance 20 cm below the wheel. Secure a string on the rim of the 12-cm wheel. Wrap the string twice around the wheel and attach a 10-g counterbalance on the opposite side 40 cm below the wheel. Record what you predict will happen when the two counterbalances are released. See Figure SP 5.8.4(5).

Prediction ______________________________

Actual events ______________________________

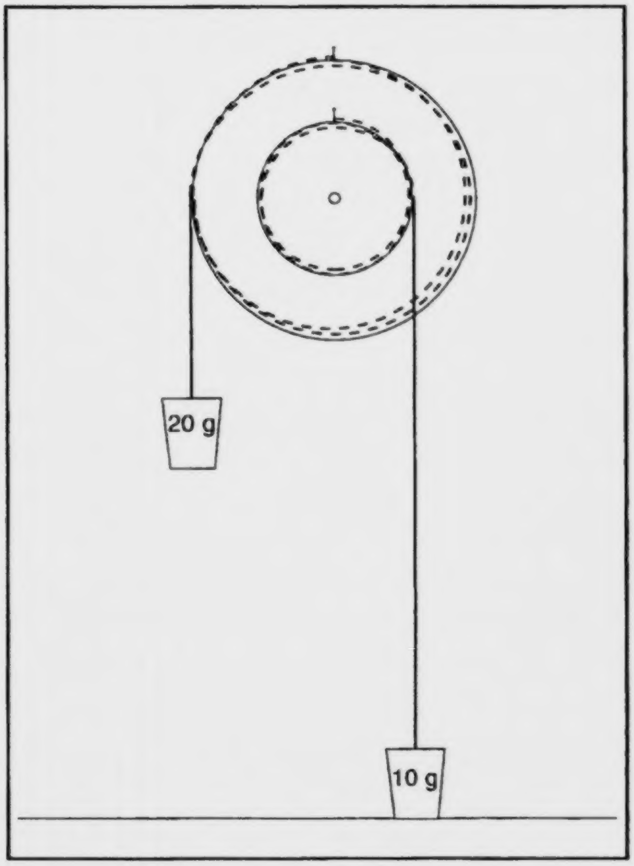

Figure SP 5.8.4(5)
Problem D Showing only the outer and middle wheels

Name ______________________

10. Explain how the system operated.

____

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____

11. Experiment with your wheels and axles and develop a rule to predict how much string will be unreeled by one wheel as another wheel reels it in.

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DASH

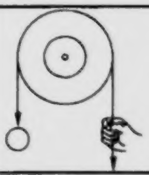
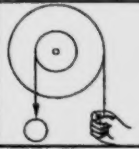
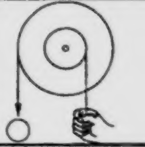
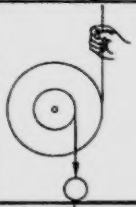
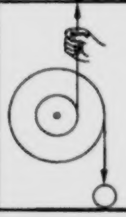
Name__________________________

Date__________________________

STUDENT PAGE 5.8.5 LEVERS

1. **Use Table SP 5.8.5-1 as a guide to set up the wheel-and-axle systems shown. Use a 20-g mass to produce a resistance (R) and determine whether the effort (E) force represented by the hand is *greater than, the same as,* or *less than* the resistance force represented by the circle. Check (✓) the appropriate cell in the table.**

Table SP 5.8.5(1) Wheel-and-axle systems

		E more than R	E less than R	E same as R
System 1				
System 2				
System 3				
System 4				
System 5				

Name ______________________________

2. On the similar lever system shown under each wheel-and-axle system in Figure SP 5.8.5(2) label the fulcrum with an (F), the resistance with an (R), and the effort with an (E).

3. In Figure SP 5.8.5(3) label the fulcrum with an (F), the resistance with an (R), and the effort with an (E).

4. There are three different locations on a lever. One is a mid-location, and there are two outside or end locations. Keeping these three locations in mind, draw all possible combinations of locations of the fulcrum (F), resistance (R), and effort (E) on the lever beams below.

_________________ _________________ _________________

_________________ _________________ _________________

_________________ _________________ _________________

Total number of possible drawing combinations ___

Total number of different actual combinations ___

5. Explain how the mnemonic below helps identify the different classes of levers.

From the middle we see
Of classes 1, 2, 3
That levers are F-R-Ē

____

____

____

____

Name ______________________________

6. Label the class of the levers similar to the wheel-and-axle systems shown in Figure SP 5.8.5(2).

7. Label the class of the levers operating in the machines shown in SP 5.8.5(4). Label the levers to show the fulcrum (F), resistance (R), and effort (E). Use arrows to show the direction of the effort and resistance.

ILLUSTRATIONS

Name ______________________________

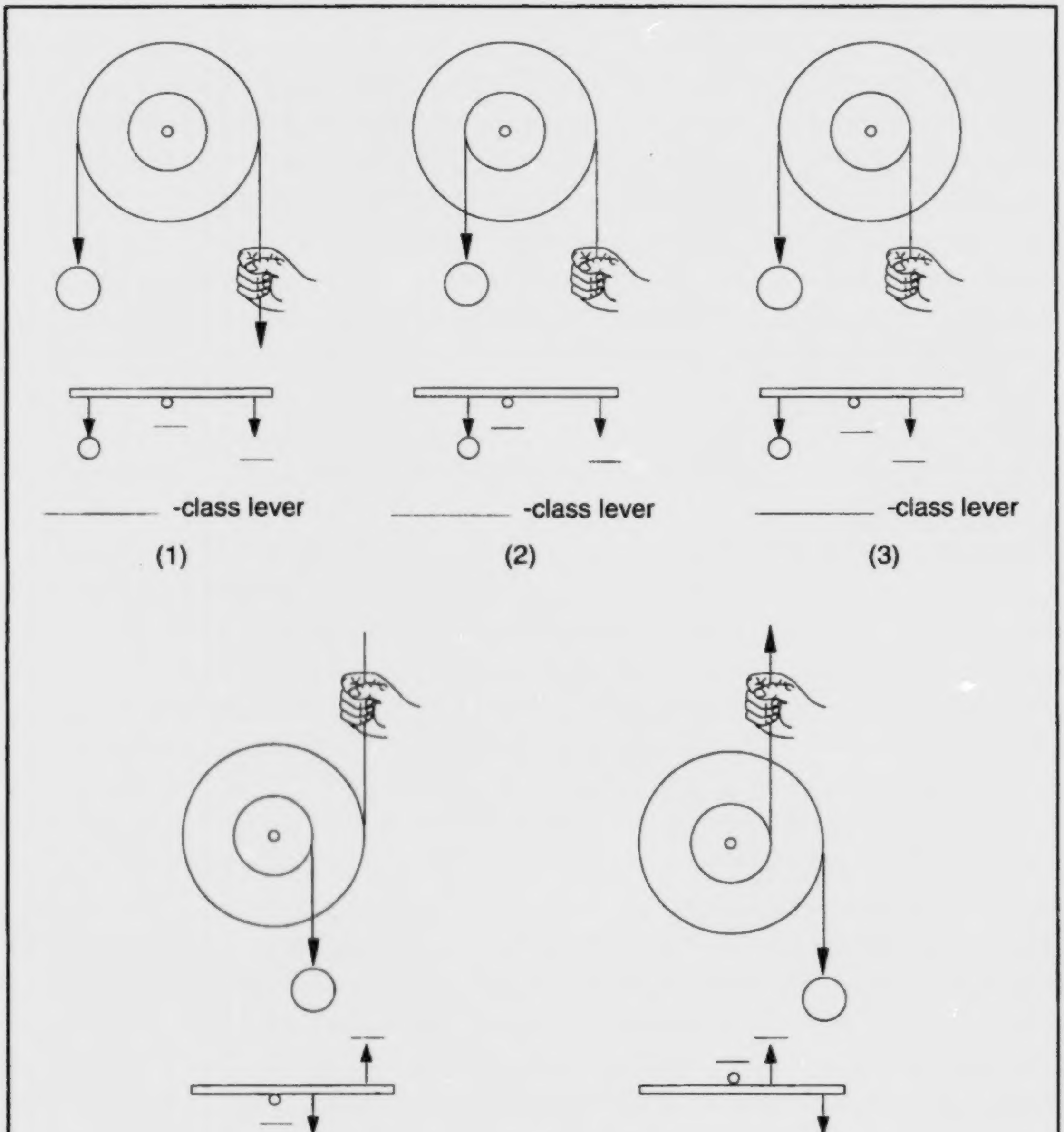
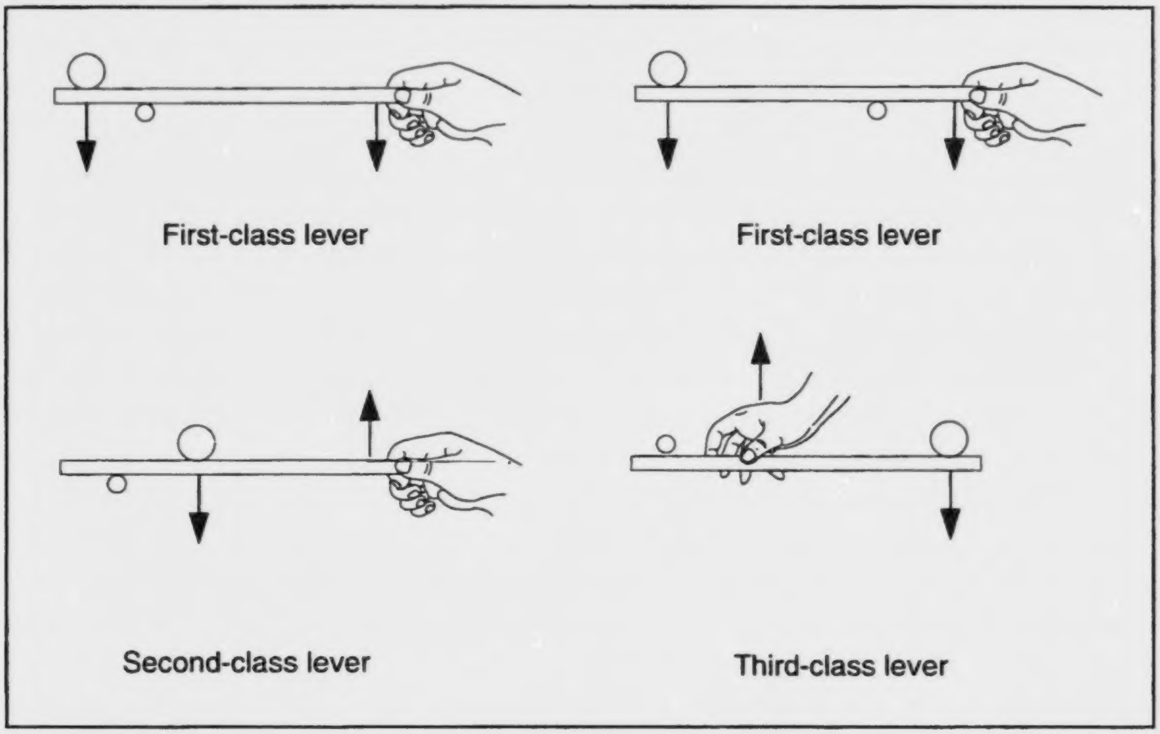

________ -class lever
(1)
________ -class lever
(2)
________ -class lever
(3)
________ -class lever
(4)
________ -class lever
(5)

Figure SP 5.8.5(2) Wheel-and-axle systems with a hand representing the effort, a circle on the string the resistance, and a small circle the fulcrum. All systems are balanced. Similar lever systems are shown.

Name ______________________________



First-class lever

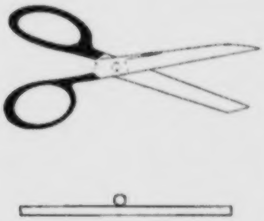
First-class lever

Second-class lever

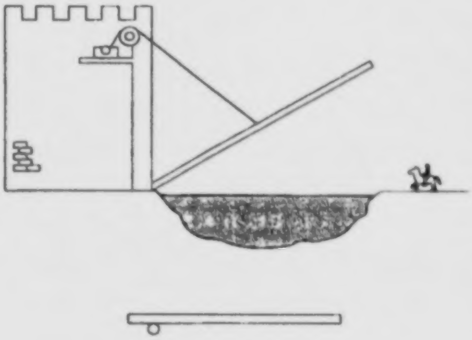
Third-class lever

Figure SP 5.8.5(3) First-, second-, and third-class levers. All levers are balanced

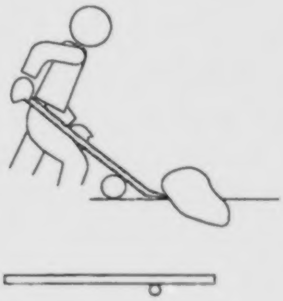
Name ______________________________



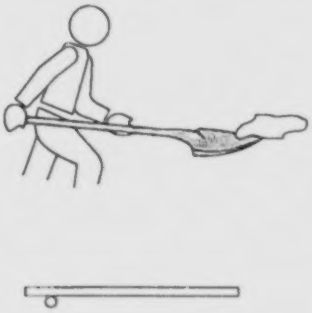
______ -class lever



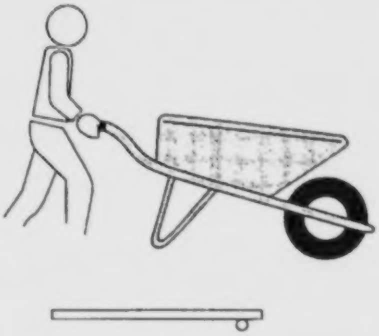
______ -class lever



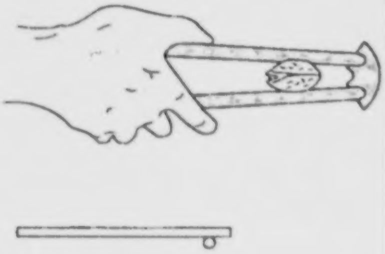
______ -class lever



______ -class lever



______ -class lever



______ -class lever

Figure SP 5.8.5(4) Various machines

DASH

Name__________________________

Date___________________________

STUDENT PAGE 5.8.6 ARMS AND JAWS

1. Cut out the bones shown in Figure SP 5.8.6(1) and assemble them into a working model of the jaw.

2. Identify the class of lever operating in the muscle-bone systems when the jaw is *opened.*

   ____

3. Identify the class of lever operating in the muscle-bone systems when the jaw is *closed.*

   ____

4. Cut out the bones on Figure SP 5.8.6(2) and assemble them into a working model of the arm.

5. Identify the class of lever operating when the forearm is *lifted* by the biceps.

   ____

6. Identify the class of lever operating when the forearm is restored to its *straightened* position by the triceps.

   ____

7. Cut out the bones in Figure SP 5.8.6(3) and assemble them into a working model of the index finger and thumb.

8. Identify the classes of levers operating to *open* your model fingers.

   ____

Name ______________________________

9. Identify the classes of levers operating to *close* your model fingers.

____

10. Follow your teacher's instruction and make a plastic-straw model of a finger.

11. Explain how your straw model of a finger is similar to and different from your actual finger.

____

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12. Identify the class or classes of levers operating to *open* your plastic-straw model of a finger.

____

13. Identify the class or classes of levers operating to *close* your plastic-straw model of a finger.

____

ILLUSTRATIONS

Name ______________________________

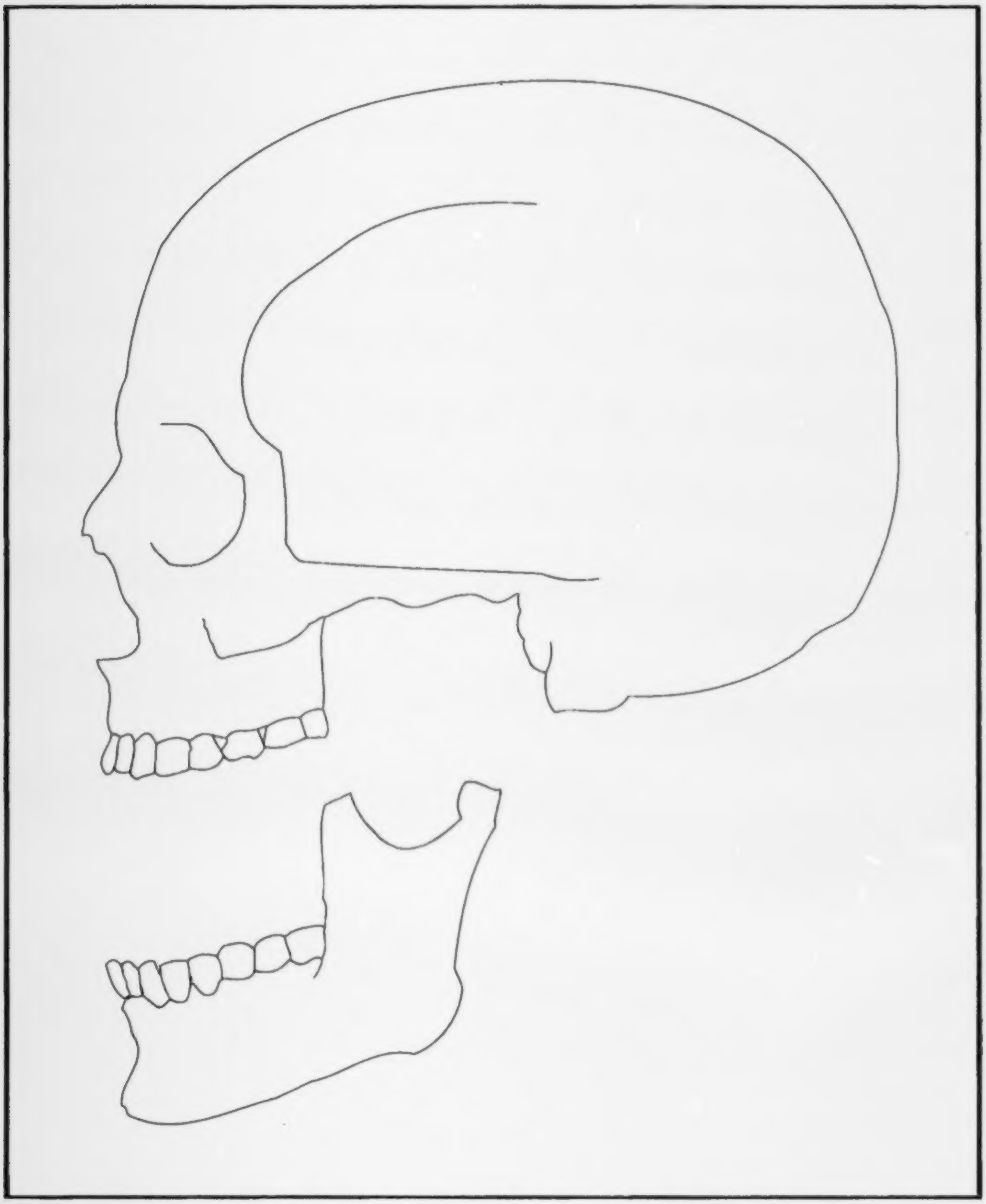

Figure SP 5.8.6(1) Skull and jaw bones

Name ______________________________

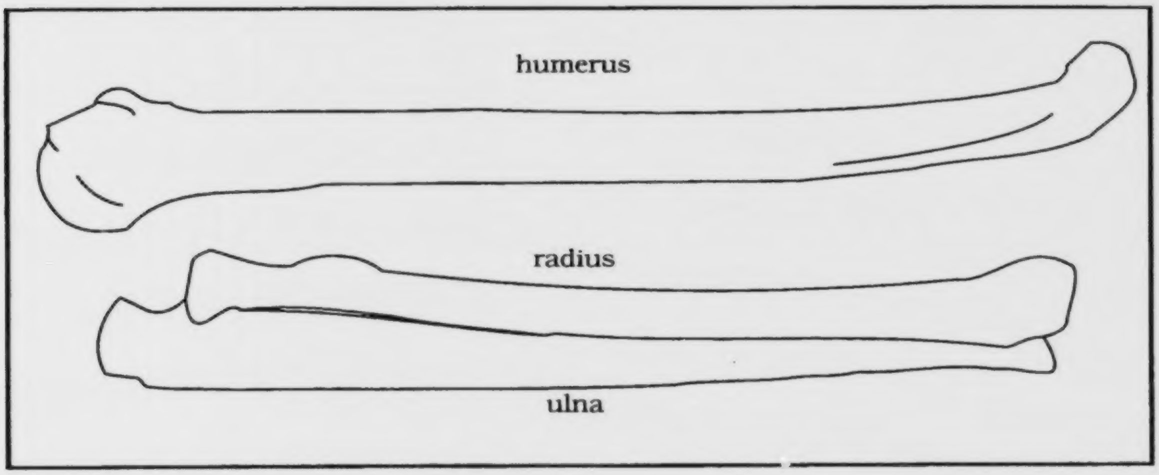
humerus
radius
ulna

Figure SP 5.8.6(2) Humerus, radius, and ulna

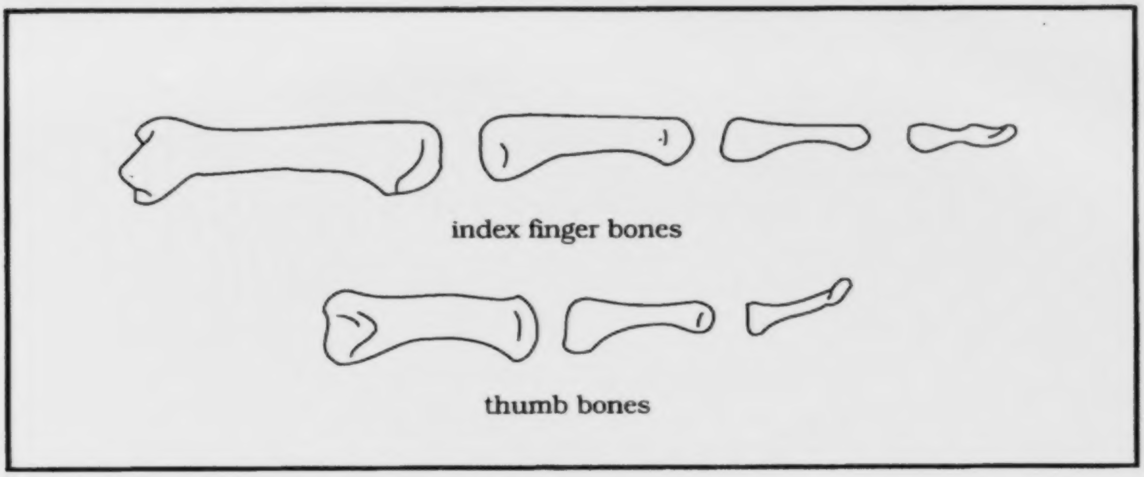
index finger bones
thumb bones

Figure SP 5.8.6(3) Index finger and thumb bones

Name________________________

Date________________________

DASH

STUDENT PAGE 5.8.7 INCLINED PLANES AND SCREWS

1. Construct a roller to use on an inclined plane. See Figure SP 5.8.7(1). Describe how you made the roller and adjusted it so that it could roll freely. Use drawings where needed.

____

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____

____

2. Construct an inclined plane and a wheel-and-axle system to help pull the roller along the plane. Make a drawing of your system.

____

____

____

____

Name ____________________________

3. **Determine the least amount of mass that produced the effort needed to pull the roller 10 cm up the inclined plane at various angles.**

	Least Amount of Mass Needed to Produce the Effort to Pull the Roller up the Inclined Plane
0°	
30°	
45°	
60°	
90°	

4. **How does the angle of the inclined plane affect the amount of counterbalance or effort needed to pull the roller up the inclined plane? What is your evidence?**

____

____

____

____

5. **Make a drawing showing how you made an inclined plane into a screw.**

Name ________________________________

6. Cut along the solid lines and make the shapes in Figure SP 5.8.7(2) into mobiles. Suspend the mobiles by thread and stabilize them with paper clips. Explain why these mobiles are inclined planes. Use drawings where needed.

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____

____

____

ILLUSTRATIONS

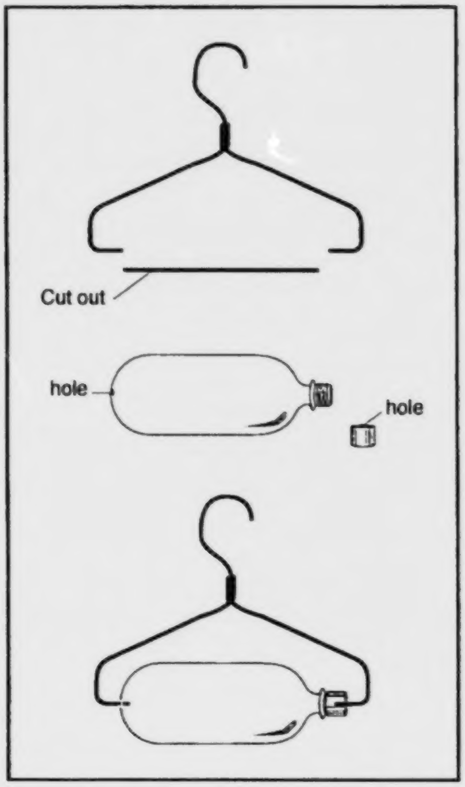

Figure SP 5.8.7(1) Inclined-plane roller

Name ____________________________

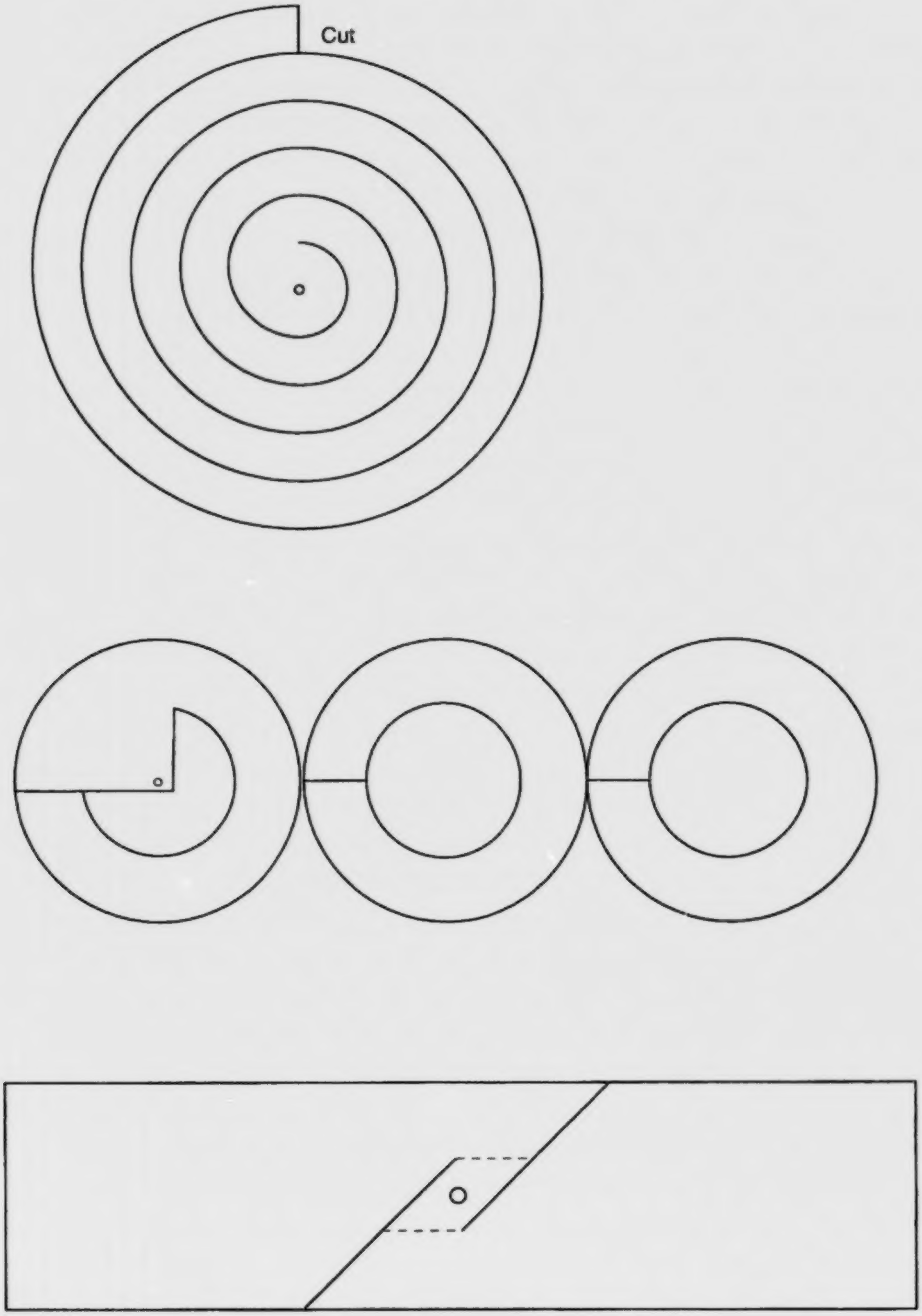

Figure SP 5.8.7(2) Inclined-plane mobiles

DASH

Name________________________

Date________________________

STUDENT PAGE 5.8.8 BLOCK-AND-TACKLE

1. Draw a block-and-tackle that allows one student to pull two other students.

2. Record the mass of the ruler-block and explain how you determined it.

Mass of the ruler-block __________

Name ______________________________

3. Use two separate sets of wheels as an upper block and a ruler-block as a lower block. The lower block produces the resistance. Use clay counterbalances to produce the effort in the following Investigations.

Investigation A. Determine the mass that counterbalances the lower block when the lower block is supported by one strand of string. Draw your system. Record the information called for in 1–3 below.

1.	Number of supporting strands	
2.	Mass producing resistance	
3.	Mass producing effort	
4.	Mechanical advantage	

Investigation B. Determine the mass that counterbalances the lower block when the lower block is supported by two strands of string. Draw your system. Record the information called for in 1–3 below.

1.	Number of supporting strands	
2.	Mass producing resistance	
3.	Mass producing effort	
4.	Mechanical advantage	

Name ____________________

Investigation C. **Determine the mass that counterbalances the lower block when the lower block is supported by three strands of string. Draw your system. Record the information called for in 1–3 below.**

1.	Number of supporting strands	
2.	Mass producing resistance	
3.	Mass producing effort	
4.	Mechanical advantage	

Investigation D. **Determine the mass that counterbalances the lower block when the lower block is supported by four strands of string. Draw your system. Record the information called for in 1–3 below.**

1.	Number of supporting strands	
2.	Mass producing resistance	
3.	Mass producing effort	
4.	Mechanical advantage	

Name

4. **Explain how we can estimate the mass producing the counterbalancing effort when using a block-and-tackle if we know the number of strands supporting the lower block.**

5. **Record your working definition of mechanical advantage. Explain how you can find the mechanical advantage of a block-and-tackle.**

6. **Determine the mechanical advantage of the block-and-tackles in Item 3, Investigations A–D. Record the mechanical advantage with the other data.**

7. **Explain how friction might affect the mechanical advantage of machines?**

DASH

Name________________________

Date________________________

STUDENT PAGE 5.8.9 FORCES PROJECT

1. Describe what the device is intended to do.

____

____

____

____

____

2. Draw your device and label each machine in it.

3. Develop a sales pitch to sell your device as the best device to do the assigned task.

____

____

____

____

____

DASH

GRADE FIVE
CLUSTER 9

Conservation, Recycling, and Decomposition

5.9.1 Class Recycling Project
5.9.2 Class Conservation Project
5.9.3 Decomposition and Archeology
5.9.4 Pollution Project

ACTIVITY 5.9.1 CLASS RECYCLING PROJECT

OBJECTIVES

The students
- Initiate a joint recycling project with second graders.
- Meet with second graders to plan for the project.
- Make arrangements and carry out the project.
- Have a seminar with second graders to report on the project.

BACKGROUND

This activity is part of the ongoing cooperative program between DASH classes at different grade levels to recycle and conserve materials and energy. It is suggested that the second grade be the companion class for the fifth grade. This continues cooperation between fifth- and second-grade classes begun with the tree-planting project. Below is a suggested school cooperation scheme with classes paired according to recycling projects.

Companion Grades	Suggested Recyclables
Grade 6 and kindergarten	Paper
Grades 5 and 2	Aluminum cans
Grades 4 and 1	Glass and plastic
Grades 3 and all classes	Materials for composting

Below are several advantages that can be gained from such cooperation:
- awareness of the importance of recycling to society
- gaining insight into the physical and intellectual growth and development of younger children
- creating a healthy sense of family within the school

In this activity the students organize to work with second-grade students on their recycling project. This will require such things as these:
- contacting a second-grade colleague to set up class interaction
- communicating a need for help by the second-grade class
- arranging a time for second-grade students to come to the fifth-grade class to tell what they need in the way of help
- creating opportunities for the fifth graders to organize to help
- arranging time for the groups to work together

Agreement about where the recyclables are to be stored and arrangements for the sale or donation of the aluminum will need to be worked out with administrative and janitorial staffs and parent-teacher groups.

STUDENT ROLE

Recycler

MATERIALS

storage bins or plastic bags
Student Page 5.9.1 CLASS RECYCLING PROJECT

PRODUCTS

Recycled materials
Completed Student Pages

PROCEDURES

1. **Arrange with a cooperating second-grade teacher to have the second graders draft a letter asking for help in working with their aluminum or other recycling project.**

   On delivery of the letter have your fifth-grade students
   - Recall the kinds of help they needed when they were second graders.
   - List the kinds of things that they can help with.
   - Draft a letter offering to meet with the second graders for a discussion.
   - Develop the agenda for the meeting.

2. **Arrange a meeting between classes.**

   Help the students decide the following:
   - Who will be their spokesperson.
   - Who will prepare and serve snacks.
   - Who will work out seating arrangements.
   - Who will keep records of the meeting.

3. **Have the two groups meet as entire classes or send delegations.**

Help the groups decide such things as these:
- How the collection is to be made.
- Who will make the collections.
- When the collection will be made.
- Where the collected items are to be stored.
- Who will arrange for the storage.
- Who will contact the recycler.
- What the role of each class will be.

4. **Carry out the recycling project and have a joint seminar on recycling with the second graders when it is completed.**

Have the students report the following:
- How much material they collected.
- What kinds of materials they collected.
- What the recycler paid for the materials if payment was received.
- Why it is important to recycle.

EXTENSIONS

Have the students
- Invite the parents' organization of the school to participate in the class recycling project.
- Videotape the stages and highlights of the project.
- Visit a recycling center.

Name________________________

Date________________________

STUDENT PAGE 5.9.1 CLASS RECYCLING PROJECT

1. Describe what was done in the class recycling project.

2. Explain why recycling is important.

ACTIVITY 5.9.2
CLASS CONSERVATION PROJECT

OBJECTIVES

The students
- Make a concept map of the term conservation.
- Plan their conservation activities.
- Assign responsibilities for conservation.
- Devise a way to measure the quantity of resources conserved.
- Devise a way to make an ongoing report to display the amount of conservation being carried out.

BACKGROUND

Conservation is a major topic throughout DASH. Each year the students have various projects to conserve the resources of the school and recycle materials. They keep an ongoing record of their conservation efforts to help make the practice of conservation routine. In this activity the students plan their conservation project, assign responsibilities, devise a way of measuring the amount of conservation, and keep a public record of their effort.

Conserving

These are some of the kinds of things the class can work at conserving:
- things that can be used over and over (pencils, erasers, crayons, clay, containers, and so forth)
- things that are only partially consumed in a single operation (paper, all kinds of building materials, and so forth)
- things that can be wasted if not turned off (electricity, water, gas, and so forth)
- things that might be used excessively (tape, glue, paper, and so forth)
- things that can be commercially recycled

STUDENT ROLE

Conservationist

MATERIALS

materials identified by students
Student Page 5.9.2 CONSERVATION PROJECT

PRODUCTS

Conserved resources
Completed Student Pages

PROCEDURES

1. **Have the students make a concept map of the term conservation.**

   Help them include such things as these:
   - Saving resources.
   - Using resources wisely.
   - Limited resources such as water and electricity.
   - Renewable resources such as forests and food crops.
   - Non-renewable resources such as oil, coal, and metals.
   - Recycling.
   - Reusing discards. (The DASH approach.)
   - Responsibility of everyone.
   - Replanting forests.

2. **Have the students work in groups to consider resources the class can conserve during the coming year.**

   Help them consider such things as
   - Conserving paper.
   - Conserving water.
   - Conserving electricity.
   - Reusing containers. (Plastic, metal, and cardboard.)
   - Reusing construction materials.
   - Recycling paper, glass, plastic, and aluminum. (See Activity 5.9.1 CLASS RECYCLING. Note that ideally the sixth graders will help the kindergartners recycle paper, the fifth graders will help the second graders recycle aluminum cans, and all DASH grades will help the third graders with composting.)

3. **Have the students make a plan for their conservation projects. Have them use Student Page 5.9.2 CONSERVATION PROJECT to record their decisions.**

   Help them include such things as these:
   - Storage.
   - Responsibility to monitor the conservation.
   - A way of measuring the amount of conservation that has taken place. (How much paper was saved by reuse, how often dripping faucets were turned off, how much electricity was saved, and so forth.)
   - A way of reporting the conservation to the public graphically.

4. **Periodically have the groups report on their success in conserving resources.**

EXTENSIONS

Have the students
- Make a plan for conserving resources at home.
- Keep a scrapbook on worldwide efforts to conserve natural resources.

DASH

Name________________________

Date________________________

STUDENT PAGE 5.9.2 CONSERVATION PROJECT

1. List the resources that you plan to conserve.

2. Describe how you will measure the amount of conservation that has taken place.

3. Describe how you will report the amount of conservation to the public.

ACTIVITY 5.9.3
DECOMPOSITION AND ARCHEOLOGY

OBJECTIVES

The students

- Unearth the materials they buried when they were in the fourth grade and check the predictions they made about their condition.
- Reflect on the kinds of evidence that archeologists might look for a hundred years from now to get clues about their class.
- Invent ways of measuring the amount of decomposition that takes place in different materials.
- Design, make, and bury a time capsule containing the record of their tree planting with second-grade students.

BACKGROUND

This activity has two investigations. In the first, the decomposition investigation, the students unearth and inspect the materials they buried when they were in DASH 4. Applying what they have learned about decomposition, they make a time capsule in the second investigation.

Decomposition Project

The decomposition investigation can be done any time during the year. After inspecting the unearthed materials the students design an experiment to measure the amount of decomposition that will take place in the materials between the reburial and the final unearthing in DASH 6.

Time Capsule

The second investigation involves designing and making a time capsule to hold records of the planting of the holiday tree with DASH 2 students. Records might include photos, speeches, and measurements of the tree. This capsule will be unearthed by the present DASH 2 students when they harvest the tree in DASH 5. This part of the activity should be started right before the planting of the holiday tree. See Activity 5.4.3 TREE PLANTING.

STUDENT ROLES

Environmentalist
Archeologist

MATERIALS

materials buried in DASH 4
shovel
materials as needed for the time capsule
records for the time capsule
Student Page 5.9.3 DECOMPOSITION AND ARCHEOLOGY

PRODUCTS

Buried materials for DASH 6
Techniques to measure the amount of decomposition in buried materials
Time capsule commemorating the planting of the seasons tree
Completed Student Page

PROCEDURES

1. **Have the students retrieve the records of the burial of materials done at the end of DASH 4.**

   Ask such questions as these:
   - What materials did you bury?
   - What were your predictions about the burial?
   - What materials did you intend to preserve?
   - Does anyone wish to change their predictions as to what we will find?

2. **Have the students dig up the material that was buried at the end of grade 4 and check their predictions.**

   Ask such questions as these:
   - How good were your predictions?
   - How successful were you in preserving food buried in grade 4? Why?
   - If you were an archeologist looking for evidence of this civilization 100 years from now, what kinds of things would be most likely to survive in the ground as a record. Why? (Explore

ideas about things that are organic [meat, vegetables, wood, and so forth] and inorganic [metal, plastic, paper glass, and so forth].)

- How would you rate the relative survival rate of these materials? Why?

3. **Have the students work in small groups to make their ratings. Have them report their ratings and come to a class consensus on what would survive best.**

4. **Have the students work in small groups to invent ways to measure the amount of decomposition that will take place between now and the final unearthing in DASH 6. Have them plan to rebury the remaining materials in the collection and add new materials to test their measuring techniques.**

   Help them consider such things as these:
   - What has happened to the buried materials in past years.
   - The amount of moisture that reached their buried materials.
   - The kinds of evidence of decomposition that they have seen in the past.
   - What could be measured or recorded. (Probe for such things as the amount of rust scraped off, a change in color, a loss in mass, crumbliness or loss of strength, and so forth.)

5. **Have the students record their predictions about the state of the materials when they are unearthed in DASH 6. Have them make whatever measurements they need and record them on Student Page 5.9.3 DECOMPOSITION AND ARCHEOLOGY.**

6. **Rebury the collection and record where the burial took place.**

7. **Have the students invent a time capsule to keep a record of the planting of a winter holiday tree with the DASH 2 students. See Activity 5.4.3 TREE PLANTING.**

   Help the students consider such things as these:
   - The kinds of things that have resisted decomposition well over the years that they have been burying them.
   - What water might do to their records.
   - How they might waterproof their capsule.

- How they can keep the capsule from being dug up by grounds crews and others. (Consider talking to your grounds crew.)
- How they can keep the capsule from being dug up by vandals.
- How they can leave a record that only the DASH 2 students could find when they come to DASH 5. (A buried treasure map.)
- If a secret burial is decided on, where the map is to be deposited.

8. **Have the students decide what they are going to include in the capsule.**

   Help them think about such things as these:
   - A picture record of the planting of the tree, their own portraits.
   - Dimensions of the tree. (Include the height-and-diameter shadow pictures.)
   - A description of how the tree was planted.
   - A guest book with the names, pictures, and signatures of all the people who were at the planting.
   - Copies of any speeches made.
   - Records of the body dimensions of both classes at the time of planting. (Include weight and height of both groups for use in Activity 5.3.11 BODY CHANGES.)

9. **Have the students design, make, and test their capsule. Have them redesign and modify as needed.**

10. **Have the students bury the capsule and leave a sealed record of the burial in the library.**

    Be sure that
    - The capsule is buried deep enough so as not to be disturbed by dogs or grounds crews—at least 2 feet beneath the surface.
    - A note is attached to the record indicating that the capsule is not to be touched until the present second-grade class reaches the fifth grade.
    - A back-up copy of **your** directions on where to find the capsule in case the students' instructions cannot be followed..

EXTENSION

- Have some students report on the article appearing in the February 1991 *National Geographic* on digging into garbage piles for a record of the past.

DASH

Name ______________________

Date ______________________

STUDENT PAGE 5.9.3 DECOMPOSITION AND ARCHEOLOGY

1. Discuss the prediction about decomposition you made in the fourth grade and what actual decomposition has occurred.

2. List the kinds of materials that have been buried since kindergarten. Order the list so that the things that have decomposed the fastest are first and the things that have decomposed the least are last.

Name______________________________

3. Record your measurements to determine quantitatively the amount of decomposition that will occur between now and the unearthing in the sixth grade. Predict the amount of decomposition that will occur in each item.

4. Describe the design of the time capsule and explain how its construction will resist decomposition.

ACTIVITY 5.9.4 POLLUTION PROJECT

OBJECTIVES

The students
- Make connections between their work in the fifth grade and the disposal, treatment, and use of school, home, community, and industrial wastes.

BACKGROUND

Pollution is a major social concern reflected throughout the DASH program. The students have been sensitized to the problem in many of their conservation and other projects.

Approach

In POLLUTION PROJECT the students are asked to connect what they have done during the year with the creation, treatment, disposal, use, and pollution potential of different kinds of waste. They are asked to assemble their reflections into a mural. This becomes a pictorial concept map.

It is suggested that the students review their Science Record Books, news articles, periodicals, and other sources for ideas. As much as possible have the students organize the mural assembly.

STUDENT ROLES

Environmentalist

MATERIALS

Science Record Books
Student Page 5.9.4 POLLUTION PROJECT

PRODUCTS

Pollution mural
Completed Student Pages

PROCEDURES

1. **Have the students make a concept map of the term pollution. Have them devise and record a working definition of the term.**

   Help them include such things as these:
   - Damaging to health of humans and other organisms.
   - Unsightly, offensive, unclean.
   - Kinds of pollution—solid, liquid, air, heat.
   - Treatment—burial, burning, decomposing, filtering, and so forth.

2. **Have the students make a concept map and definition of the term waste. Have them devise and record a working definition of the term.**

   Help them include such things as these:
   - Garbage and refuse from home, industry, or other institutions.
   - Biological waste—sewage and garbage.
   - Non-biological waste—ash, metals, plastics, chemicals (solid, liquid, and gas).
   - Energy waste—atomic radiation, heat.
   - Sources—animals, plants, cars, industry, war, and so forth.
   - Treatments—burial, burning, decomposing, filtering, storing, and so forth.

3. **Introduce the project of making a mural showing how the things studied during the year are connected to understanding waste—its creation, handling, use, disposal, pollution potential, and control.**

4. **With each pictorial example of the mural have the students write a brief description of its connection with what they have studied. See Student Page 5.9.4 POLLUTION PROJECT.**

5. **Summarize the activity.**

   Ask such questions as these:
   - What are the most common ways of getting rid of biological waste and pollution?

  - What are the most common ways of getting rid of industrial waste and pollution?
  - Are there some fuels that produce less waste and pollution than others? What are they?
  - What are some ways that we as individuals can reduce waste and pollution?

EXTENSION

- Have the students share their work with other classes.

DASH

Name__________________________

Date___________________________

STUDENT PAGE 5.9.4 POLLUTION PROJECT

List the connections you have found between pollution and the kinds of things you have explored in DASH. Use your pollution mural as a source of connections and add other connections that you think of.

DASH

Name__________________________

Date___________________________

STUDENT PAGE 5.9.1 CLASS RECYCLING PROJECT

1. Describe what was done in the class recycling project.

2. Explain why recycling is important.

Name________________________

Date________________________

STUDENT PAGE 5.9.2 CONSERVATION PROJECT

1. List the resources that you plan to conserve.

2. Describe how you will measure the amount of conservation that has taken place.

3. Describe how you will report the amount of conservation to the public.

DASH

Name ____________________

Date ____________________

STUDENT PAGE 5.9.3 DECOMPOSITION AND ARCHEOLOGY

1. Discuss the prediction about decomposition you made in the fourth grade and what actual decomposition has occurred.

2. List the kinds of materials that have been buried since kindergarten. Order the list so that the things that have decomposed the fastest are first and the things that have decomposed the least are last.

Name ________________________________

3. Record your measurements to determine quantitatively the amount of decomposition that will occur between now and the unearthing in the sixth grade. Predict the amount of decomposition that will occur in each item.

4. Describe the design of the time capsule and explain how its construction will resist decomposition.

Name____________________________

Date_____________________________

STUDENT PAGE 5.9.4 POLLUTION PROJECT

List the connections you have found between pollution and the kinds of things you have explored in DASH. Use your pollution mural as a source of connections and add other connections that you think of.

DASH

GRADE FIVE
CLUSTER 10

Matter, Space, and Construction

5.10.1 Linear Measurement
5.10.2 Volume Measurement
5.10.3 Camera Obscura
5.10.4 Controlling Light with Lenses
5.10.5 Making a Telescope
5.10.6 Stabilizing the Telescope
5.10.7 Making a Microscope
5.10.8 Making a Hygrometer
5.10.9 Making a Barometer

ACTIVITY 5.10.1 LINEAR MEASUREMENT

OBJECTIVES

The students
- Make two linear measurement tools—meter-string cans and metric tapes.
- Calibrate these tools in meters, decimeters, centimeters, and millimeters using the Pythagorean or other methods of line division.
- Read the history of linear measurement systems.

BACKGROUND

Each year DASH students make their own measuring tools. Work in DASH 5 provides a greater degree of precision with devices built around a prototype quarter meter. In this activity they simulate the experience of the original designers of the metric system.

In the series on measurement there are four activities: 5.10.1 LINEAR MEASUREMENT, 5.6.1 GROWTH CHART AND AREA MEASUREMENT, 5.10.2 VOLUME MEASUREMENT, and 5.8.3 THE BALANCE. When possible, this order should be followed.

In LINEAR MEASUREMENT the students make a paper metric tape and a meter-string can with a string at least 10 meters long. They begin the activity by reading a brief history of the metric system on Student Page 5.10.1A THE METRIC SYSTEM AND LINEAR MEASUREMENT.

Meter Tape

Figure SP 5.10.1A shows a line 25 cm or 1/4 meter long. The students use this line to mark a 1-meter interval on adding machine tape. Once the meter interval is marked, they divide the entire tape into decimeters, the first quarter of the tape into centimeters, and the first centimeter into millimeters.

Have the students invent a way to fold, protect, and store their metric tape because they will use it often.

Meter-String Can

If the students have not had DASH previously, it will be helpful to show them a sample meter-string can with a string at least 10 meters long. See Figure 5.10.1(1). For permanence the meter points should be encased in masking tape. The meter at the free end of the string should also be encased in masking tape and calibrated in decimeters. The last decimeter should be calibrated in centimeters. See Figure 5.10.1(2).

Calibration

Students who have made metric tapes before should be able to continue with minimum instruction. It is a good idea to have experienced students work with students new to DASH. There are substantial new tasks in this activity—construction of a meter interval from 25-cm intervals and division of a centimeter into millimeters. Encourage the students to try their own methods of calibration before giving them any clues about making the divisions.

Pythagorean Method of Line Division

The Pythagorean method of line division can be used to divide the metric tape into centimeters in the following way:

- Fold the 1-meter tape into 50-centimeter segments and then into 25-centimeter segments.
- Use a sheet of lined notebook paper to divide the first 25-centimeter segment into single centimeters. Mark succeeding lines on the paper *0* to *25*. Place the tape diagonally across the lines so that the end of the tape is on line 0 and the 25-centimeter point is on line 25.
- Mark a centimeter wherever a line touches the tape.

Figure 5.10.1(3) shows a piece of tape being marked into four segments using the Pythagorean method. The tape can be divided into millimeters in a similar way. See Figure 5.10.1(4). The students should invent their own method for dividing the meter into decimeters.

STUDENT ROLES

Physicist
Geometer

MATERIALS

coffee or similar can with plastic lid
string
masking tape
washer or other object to secure string in the can
lined notebook paper
pencil
pen to mark masking tape

adding machine tape
Student Pages 5.10.1A THE METRIC SYSTEM AND LINEAR MEASUREMENT
5.10.1B LINEAR MEASUREMENT

PRODUCTS

Calibrated metric tape
Calibrated meter-string can
Completed Student Pages

PROCEDURES

1. **Have the students read Student Page 5.10.1A THE METRIC SYSTEM AND LINEAR MEASUREMENT. Explain that we are going to make our own measuring tools. To do this we have a measurement 1/40,000,000 (one forty-millionth) the distance between the poles. See Figure SP 5.10.1A.**

   Ask such questions as these:
   - How was the meter originally measured? (It was measured as 1/10,000,000 of the distance between the poles and the equator.)
   - How large is 1/40,00,0000 compared to 1/10,000,000? (Work for agreement that it is 1/4 as large.)
   - What part of a meter is this? (Work for agreement that it is 1/4 of a meter.)
   - How many centimeters is this? (Work for agreement that this is 25 cm.)

2. **Have the students make a 1-meter tape using the previously measured 25-cm interval. Divide the first quarter (25 cm) into centimeters, the first centimeter into 10 millimeters, and the entire tape into decimeters.**

   You may need to demonstrate the Pythagorean method after the students have tried to make the divisions themselves.

3. **Have the students compare their metric tape and its subdivisions with a commercial meterstick.**

   Ask such questions as these:
   - How close is your metric tape to the commercial meterstick? (They will normally be very close. If not, allow the students to adjust their tapes.)

- Is the commercial meterstick a perfectly accurate meter? (Work for the idea that it is a copy, probably a copy of a copy, and that every time we copy something there will be slight errors.)
- When we measure the length of something, what do we mean? (Work to the idea that we are comparing something with a standard.)
- Are there other standard measurements of length? (Point out that our common U.S. system is another system.)
- Is any system of length measurement better than others? (Ask the students which system they prefer and why.)

4. **Introduce the need for a metric linear measurement device 10 meters long. Discuss how to make a meter-string can and how to calibrate it.**

   Ask such questions as these:
   - How can we secure the string in the can?
   - How can we keep the ends of the string from fraying? (Knot the ends. If nylon string is used, melt the ends with a flame.)
   - From where to where do we measure 10 meters? (From the can to the knot at the end of the string.)
   - How long should the string be? (Ten meters plus an extra amount to secure it inside the can and tie a knot on the end.)
   - How can we make permanent marks on the string? (Place masking tape at the meter points and mark it.)
   - Where would the first meter be? At the can end? At the free end? Why? (Work to the idea that it should be at the free end. Because this is where the string first comes off the can, it is the part of the string that will be used the most.)

5. **Have the students make their meter-string can.**

   Have them
   - Mark off the string in meters with the first meter marked off in decimeters and the first decimeter marked off in centimeters.
   - Check the cans and markings for accuracy by comparing them.

EXTENSION

- Have the students determine what body parts they can use to approximate a meter, a centimeter, a millimeter. This will vary from student to student but will give them a field instrument.

ILLUSTRATIONS

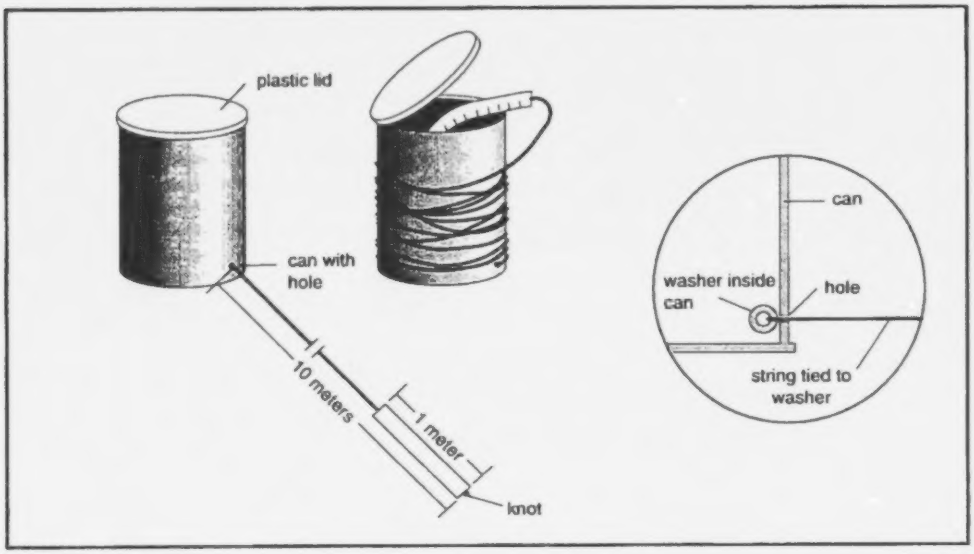
plastic lid
can with hole
10 meters
1 meter
knot
can
washer inside can
hole
string tied to washer

Figure 5.10.1(1) Meter-string can

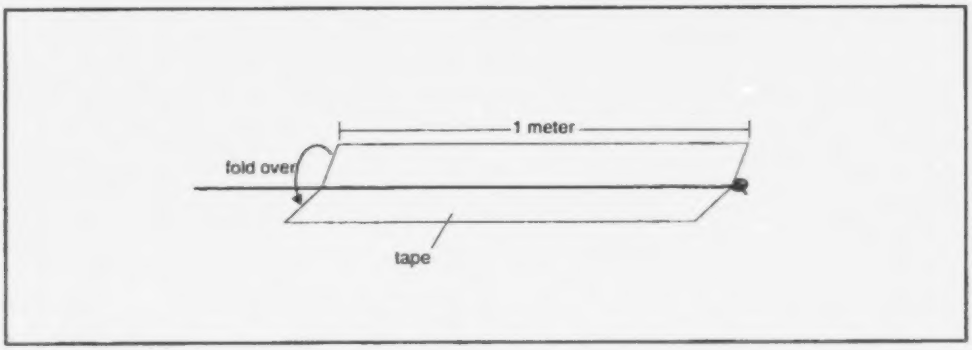
1 meter
fold over
tape

Figure 5.10.1(2) Taping the free end of the string

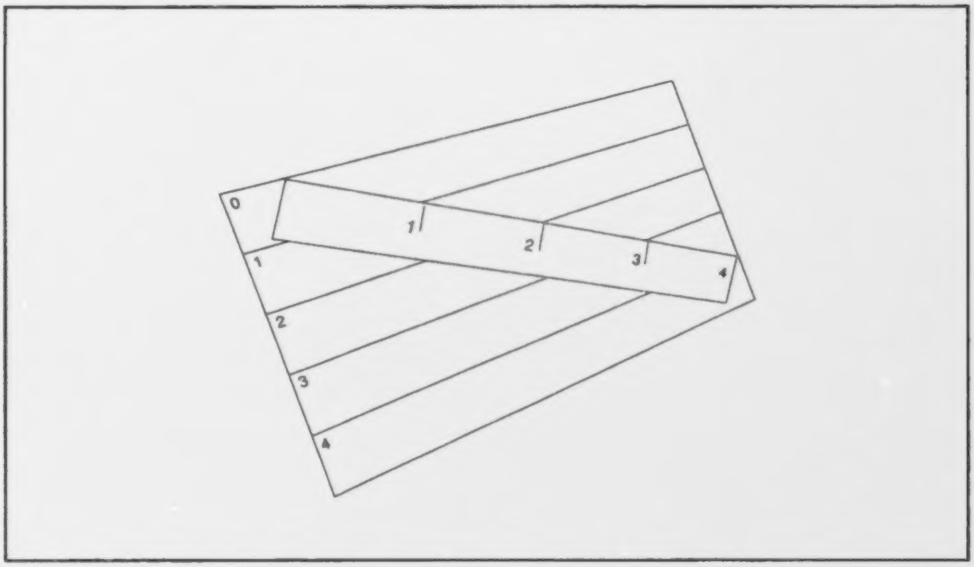

Figure 5.10.1(3) Using the Pythagorean method to divide a tape into four segments

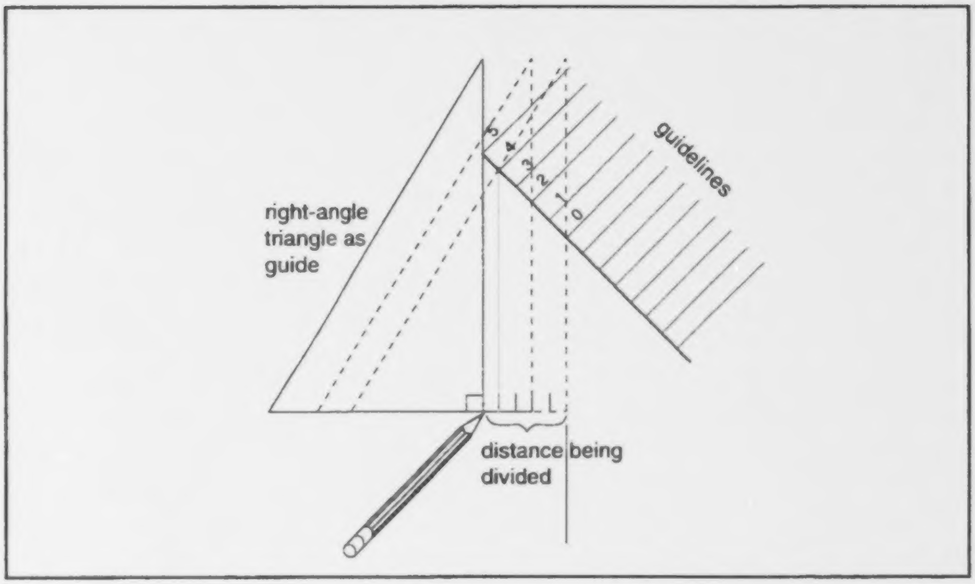
guidelines
5
4
3
2
1
0
right-angle triangle as guide
distance being divided

Figure 5.10.1(4) A method for dividing distances smaller than the space between parallel guidelines

DASH

Name________________________

Date ________________________

STUDENT PAGE 5.10.1A
THE METRIC SYSTEM AND LINEAR MEASUREMENT

Paris, France, 1791. King Louis XVI and Queen Marie Antoinette have been removed from power, and a revolutionary council governs the country. It is a time of social upheaval. Yet it is the time when a report of great historic importance is made by members of the Paris Academy of Science to the French National Assembly. The subject of their report is a system of weights and measures that will become known as the *metric system.*

This report calls for a system to be built around the measurement of the distance between the North Pole and the equator. The standard of distance, called the "meter," is to be one ten-millionth (1/10,000,000) part of that distance. The idea is accepted, and the distance is measured using the most advanced techniques of the day. A platinum bar is carefully marked to preserve this length. This original standard will be very close in length to the modern meter.

Eighty-four years later in 1875 the metric system becomes the international system for scientific measurement. A replica of 1/40,000,000 the distance from the North Pole to the equator appears in Figure SP 5.10.1A.

The Dollar and the Meter

The metric system uses units that are multiples of tens and tenths just like our U.S. system of money. A meter, like the dollar, is the basic unit. The decimeter is like our dime. It is one-tenth of the meter. The centimeter is one-hundredth of a meter. It is like our cent or penny, and the millimeter is one-thousandth of a meter and is like our mill. The mill is one-tenth of a cent and is a money unit sometimes used in taxing property.

Name ______________________

Table SP 5.10.1-1 The metric system and U.S. units of money

Metric Distance	Parts of a Meter	Money	Parts of a Dollar
millimeter (mm)	1/1000	mill	1/1000
centimeter (cm)	1/100	cent	1/100
decimeter (dm)	1/10	dime	1/10
meter (m)	1	dollar	1
kilometer (km)	1000		

U.S. System of Linear Measurement

The U.S. system for measuring distance came from Britain, and this is where it gets the name “British” or “English” system. Its yard, foot, and inch are very old measures. Originally, a yard measured the distance from the tip of the nose to the tip of the fingers on an extended arm. A yard was convenient for measuring cloth. The length of the foot was originally a measure from heel to big toe.

In the United States these measurements were standardized in 1893. At that time a copy of the international meter and the standard yard was set at 0.91 of a meter.

Table SP 5.10.1-2 Metric and U.S. linear units

Metric System		U.S. System	
centimeter	=	0.39	inches
inch	=	2.54	centimeter
meter	=	39.37	inches
kilometer	=	0.62	miles

Name ______________________

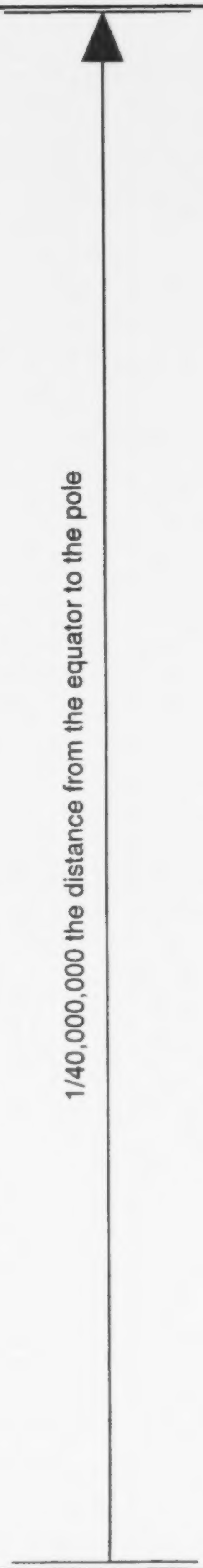
1/40,000,000 the distance from the equator to the pole

Figure SP 5.10.1A Line 1/40,000,000 the standard measurement of the distance from the equator to the poles

DASH

Name________________________

Date________________________

STUDENT PAGE 5.10.1B LINEAR MEASUREMENT

1. List advantages of the metric linear measurement system over the U.S. system.

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2. List advantages of the U.S. linear measurement system over the metric system.

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ACTIVITY 5.10.2 VOLUME MEASUREMENT

OBJECTIVES

The students
- Use a rectangular container to measure a standard volume of water.
- Make and calibrate a set of graduated metric cylinders.
- Calibrate their graduate using the Pythagorean method of division.

BACKGROUND

This is the third activity in the series on measurement. It should follow Activities 5.10.1 LINEAR MEASUREMENT and 5.6.1 GROWTH CHARTS AND AREA MEASUREMENT and precede 5.8.3 THE BALANCE. A brief history and description of the metric and U.S. systems of volume measurement appear in the student pages.

Approach

In VOLUME MEASUREMENT the students use their knowledge of volume and division of lines to calibrate a set of graduated cylinders. The students' mathematical background will determine the appropriate approach.

Situation A. The students can handle multiplication and division of decimals or you want to work through the math with them.

Work through Procedures 1–3 and 5–8. In Procedure 2 help the students explore or lead them through the following steps:
- Measure the area of the bottom of a sturdy square-bottomed pint or 473-mL waxed-paper milk or juice carton. Have them refer to Student Page 5.10.2A THE METRIC SYSTEM AND VOLUME MEASUREMENT for techniques. Many pint paper cartons have a base of 49 cm^2. A vertical height of 8.2 cm will provide a close approximation of the desired 400 mL.
- Fold down the top flaps to reinforce the mouth of the container. See Figure 5.10.2(1).
- Calculate the height 400 mL of liquid will rise in the carton when the base is 49 cm^2.
- Measure out this volume of water and use it as a liquid standard.

Situation B. The students cannot yet handle multiplication and division of decimals or you decide against doing these measurements.

Carry out Procedure 1, then complete Procedures 4–8. In Procedure 4 provide a standard 500 mL of liquid by using a half-liter juice or other bottle with commercially measured contents. Have the students do the following:

- Permanently mark the level of the commercial liquid to create the class standard.
- Use the class standard to deliver 500 mL of water.
- Fill and mark other containers for use as graduates.
- Calibrate their graduates.

Precision

As in the case of the standardized meter, a highly precise copy of a commercial graduated cylinder is not required. In particular, the initial measurement of 400 or 500 mL of water should be done with care, but the precision need not be exact. Within the range of measurements the students will need to make, the class-made standard will be adequate.

Calibrating

Have the students calibrate two containers: one a straight-walled plastic or glass pint container; the second, a clear 35-mm film canister. Where possible, the graduates should be made using the same type of containers. The 400- or 500-mL containers should be calibrated in 50-mL subdivisions with the top 50 mL in 10-mL units. Measurements of small quantities of liquid can be done with the smaller plastic graduates.

Calibrating the 400-mL or 500–mL graduate in 50-mL units can be done several ways. Two are shown here.

Technique 1: Have the students subdivide volumes by comparing heights. See Figure 5.10.2(2).

Technique 2: Have the students use the Pythagorean method to subdivide the volumes of straight-sided containers. See Figure 5.10.2(3).

Small Graduates

Start with a carefully measured 20-mL portion of water poured from the 400- or 500-mL container. Make a class standard. Have the students use the standard to calibrate their smaller graduates into 2-mL subdivisions using the Pythagorean method.

STUDENT ROLES

Physicist
Instrument maker

MATERIALS

unopened commercial 1/2-liter bottle of soda or juice
metric ruler
pint or 1/2-liter rectangular containers to hold liquids (milk or juice cartons)
pint clear-glass or plastic containers with straight sides
clear plastic 35-mm film canisters
masking tape
narrow plastic tape to write on
Student Pages 5.10.2A THE METRIC SYSTEM AND VOLUME MEASUREMENT
5.10.2B VOLUME MEASUREMENT

PRODUCTS

A set of graduated cylinders for liquid volume measurement
Completed Student Pages

PROCEDURES

1. **Discuss using and making a graduated cylinder. Have the students read Student Page 5.10.2A THE METRIC SYSTEM AND VOLUME MEASUREMENT.**

   Ask such questions as these:
   - What do we use a graduated cylinder for?
   - How have we calibrated our graduates in the past?

SITUATION A

2. **Have the students explore ways they can use a cardboard 1-pint milk carton to measure out 400 mL (cm^3) of water. Have them use one of their methods to measure out 400 mL of water.**

3. **Review the techniques used to calculate and measure out 400 mL of water.**

Ask such questions as these:

- Who can demonstrate how to get 400 mL of water? (Probe for the different ways that were used by the students.)
- How can we determine whether we all got the same amount of water? (Have the students compare the amounts of water.)
- How could we explain the differences? (Review the arithmetic and measurement techniques.)
- How can we get a container standardized to hold 400 mL? (Have the class arrive at a generally accepted "best" method and use this or other to get a class standard 400-mL container.)

SITUATION B

4. **Have the students use an unopened half-liter soda or other commercial container and mark the level of the liquid on the bottle to act as a class standard.**

5. **Discuss the problems in calibrating a jar.**

   Ask such questions as these:

   - What problems does a rounded bottom present in calibrating a graduate? (Get at the idea that it is difficult to measure the amount in the bottom. If the technique of dividing liquids into equal volumes is used, the rounding will make no difference. It will be a concern if we use the Pythagorean method of line division. The Pythagorean technique can be used to divide a known volume above the rounded part of the graduate.)
   - How can we calibrate a 500-mL graduate in 50-mL intervals?

6. **Have the students explore ways to calibrate a 500-mL container in 50-mL intervals. Have them share their techniques, standardize their measurements, and mark their containers.**

7. **Have the students explore ways to calibrate the 50-mL marking at the top of their graduate in 10-mL intervals. Have them share their techniques, standardize their measurements, and mark their containers.**

8. **Have the students invent a way to make a 20-mL graduated cylinder using a straight-walled plastic or glass container. The graduate should be calibrated in 2-mL intervals. Have the students work from a class standard.**

   Have them share their techniques, standardize their measurements, and mark their vials.

EXTENSIONS

As a science center activity have the students do the following:
- Calibrate a graduate in pints, cups, and teaspoons.
- Calibrate a 1000-mL graduate in 20-mL intervals.

ILLUSTRATIONS

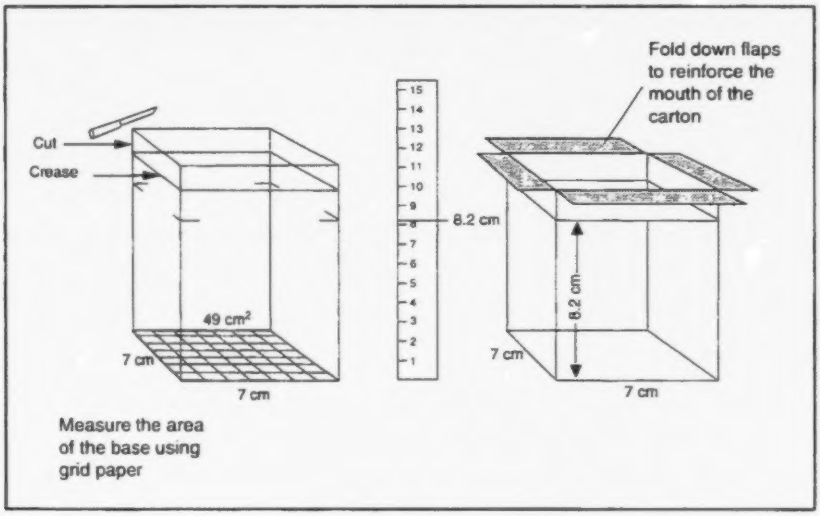
Cut
Crease
49 cm^2
7 cm
7 cm
Measure the area of the base using grid paper
15
14
13
12
11
10
9
8
7
6
5
4
3
2
1
8.2 cm
Fold down flaps to reinforce the mouth of the carton
8.2 cm
7 cm
7 cm

Figure 5.10.2(1) Making a 400-mL graduate from a pint (473 mL) milk or juice carton

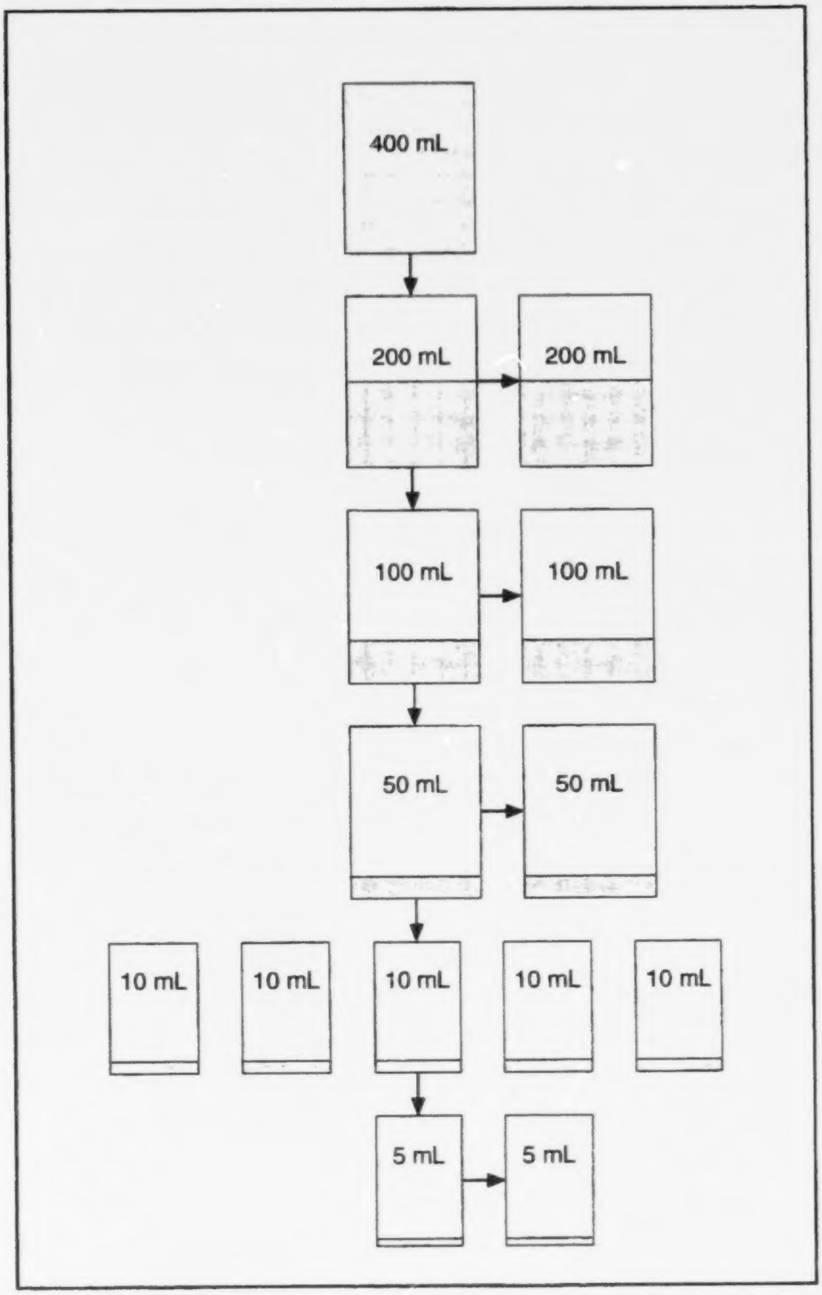
400 mL
200 mL
200 mL
100 mL
100 mL
50 mL
50 mL
10 mL
10 mL
10 mL
10 mL
10 mL
5 mL
5 mL

Figure 5.10.2(2) Subdividing volumes by comparing heights

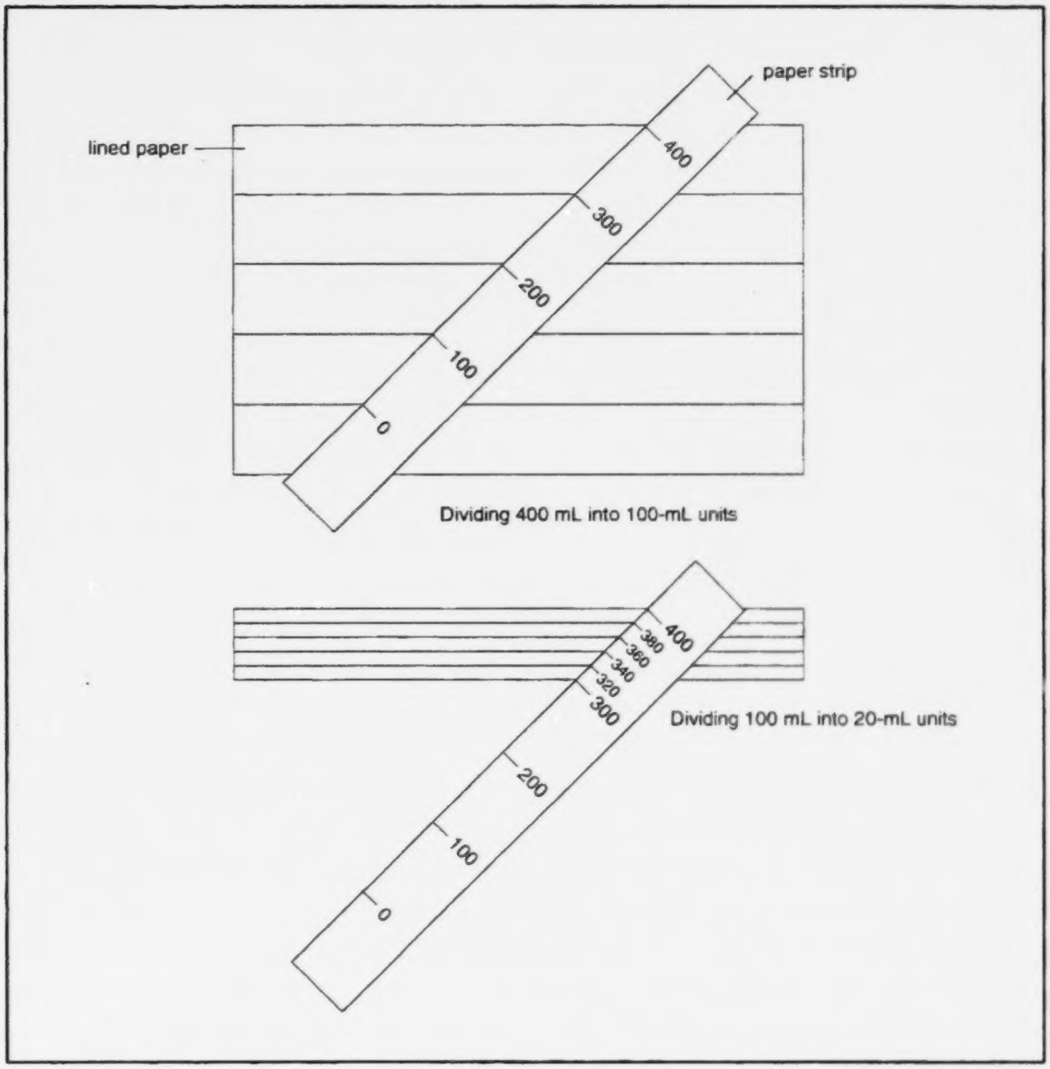
paper strip
lined paper
400
300
200
100
0
Dividing 400 mL into 100-mL units
400
380
360
340
320
300
200
100
0
Dividing 100 mL into 20-mL units

Figure 5.10.2(3) Dividing volumes using the Pythagorean method

DASH

Name__________________________

Date__________________________

STUDENT PAGE 5.10.2A
THE METRIC SYSTEM AND VOLUME MEASUREMENT

The *volume* of a thing is the space that it fits into or occupies. In the measurement of volume we determine how many cubes of some size can fit into the space the object occupies. The cube we use in the metric system is the cubic centimeter (cm^3 or cc). Each edge of this cube is 1 centimeter long.

Measuring the Volume of Boxes

It is easy to measure the volume of a box by using a piece of grid paper marked off in centimeter squares to tell us how many centimeter cubes will fit on the bottom of the box. Then we find out how many layers of these cubes it will take to fill the box. This we can find by using a ruler to measure how many centimeters there are from bottom to top. See Figure SP 5.10.2A. In the examples Box A has 8 centimeter cubes (2 layers of 4 cubes), Box B has 9 centimeter cubes (3 layers of 3 cubes), and Box C has 12 centimeter cubes (3 layers of 4 cubes).

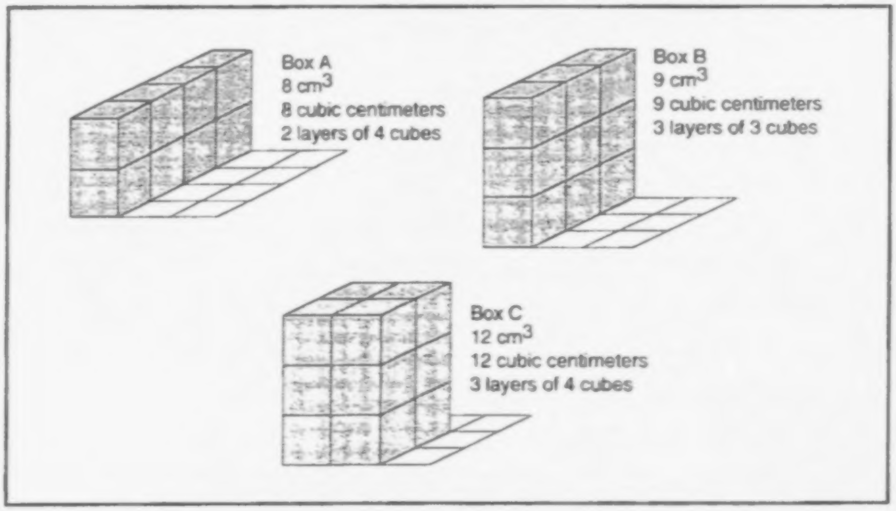
Box A
8 cm^3
8 cubic centimeters
2 layers of 4 cubes
Box B
9 cm^3
9 cubic centimeters
3 layers of 3 cubes
Box C
12 cm^3
12 cubic centimeters
3 layers of 4 cubes

Figure SP 5.10.2A Boxes with volumes of 8, 9, and 12 cubic centimeters

Name________________________________

Calculating Volume

We could arrive at the same answer by multiplying the number of centimeters along the length of the bottom of the box times the number along the width of the bottom times the number making up the height of the box.

Volume of Liquids

The common metric units used to report the volume of liquids are the milliliter (mL) and the liter (L). A milliliter is equal to 1 cubic centimeter, and a liter is equal to 1000 cubic centimeters.

The U.S. System of Volume Measurement

Volume measurement in the U.S. system is done the same way it is in the metric system. Common units of volume are the cubic inch (in^3) and the cubic foot (ft^3).

The U.S. units used to report the volume of liquids are the gallon, quart, pint, cup, and tablespoon. These units are often found in cooking.

Table SP 5.10.2A-1 U.S. liquid units

Unit	Equivalent
gallon (gal)	4 quarts
quart (qt)	2 pints
pint (pt)	2 cups
cup	16 tablespoons

Table SP 5.10.2A-2 Metric and U.S. volume measurements

U.S. Unit	Metric Equivalent
1 cubic inch	about 16 cubic centimeters
1 quart	about 1 liter

DASH

Name__________________________

Date__________________________

STUDENT PAGE 5.10.2B VOLUME MEASUREMENT

1. Describe how you used a milk carton to measure out 400 mL of water.

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2. Describe how you calibrated your large container in 50-mL intervals.

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____

3. Describe how you calibrated the first 50-mL interval in 10-mL intervals.

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4. Describe how you calibrated your 20-mL graduated cylinder in 2-mL intervals.

____

____

____

ACTIVITY 5.10.3 CAMERA OBSCURA

OBJECTIVES

The students

- Review previous work with the camera obscura.
- Invent a back-viewing camera obscura.
- Make generalizations about the optical qualities of the camera.
- Determine that the image is always inverted.

BACKGROUND

This is the first of a series of activities on light and lenses. In this activity the students return to the camera obscura to analyze how it works. DASH students have used this type of camera in the observation of the sun and eclipses since DASH 2. In DASH 5 they find that as light from an object passes through a small pinhole, the image of the object is inverted. They then invent a camera with a back-viewing screen that becomes the prototype for later work on lenses for telescopes.

Getting a Camera Obscura

Make a camera obscura or borrow one from the second grade to get started. See Figure 5.10.3(1). To make a camera obscura, cut a hole about 3 cm square in one side of a box. Cover the square with aluminum foil and poke a small hole in the foil with a pencil lead. The box should keep out as much light as possible except that from the pinhole. The size of the hole can be varied to test the sharpness of the image. A trouble lamp makes an excellent light source.

Back-viewing Camera Obscura

A shoe box makes a good back-viewing camera. See Figure 5.10.3(2). When an image is cast on a movable screen of waxed paper, the image will always be in focus. This is easily tested in a shoe box and leads to finding that the size of the image is directly related to the distance between the pinhole and the screen. The image is also always inverted.

STUDENT ROLES

Astronomer
Physicist

MATERIALS

camera obscura or cardboard box
shoe boxes
scissors
aluminum foil
masking tape
waxed paper
Student Page 5.10.3 CAMERA OBSCURA

PRODUCTS

Back-viewing camera obscura
Completed Student Pages

PROCEDURES

1. **Have the students make or borrow a camera obscura to look at things that are relatively close and brightly lighted. A light bulb will work well. Have the students work with the camera and use Student Page 5.10.3 CAMERA OBSCURA to draw the camera and explain how it works.**

   Ask such questions as these:
   - What do we mean by "image"? (Help the students develop a working definition. Work toward the idea of a likeness or a picture produced by light—something that is seen, something that can be cast on a screen. Have this recorded in the Working Dictionary.)
   - Where is the image in the camera obscura? (Have the students note that it is found on the screen in a straight line with the object, the thing we are looking at, and the hole in the camera.)
   - How does the image compare with the object we are looking at? (Get at the observation that the image is upside down compared to the object and not as bright. Have the students draw a picture showing this on Student Page 5.10.3.)
   - How might we build a camera to see the object from behind the screen? (Work to the idea that we might use a partially transparent material such as waxed paper for the screen.)

2. **Have the students engineer a back-viewing camera obscura.**

Summarize the investigation with such questions as these:

- How did you make your back-viewing camera obscura?
- How does the image look in the back-viewing camera compared to the other camera obscura? (Help the students observe that the image is still upside-down and that it requires a fairly dark enclosure to be seen in detail.)

3. **Have the students work to make a camera with as large an image as possible.**

Summarize with such questions as these:

- What did you have to do to make the picture progressively larger? (Have the students note that the farther the screen is moved from the hole, the larger the image.)
- What happened to the detail of the image as its size got larger? (Help the students observe that the image is always in focus and can be seen clearly but more dimly as the distance from the hole increases.)
- What would we have to do to make our camera obscura into a "real" camera that can take pictures. (Get at the idea that we would have to have some sort of light-sensitive film.)

EXTENSION

- Have the students help the second graders make their camera obscuras.

ILLUSTRATIONS

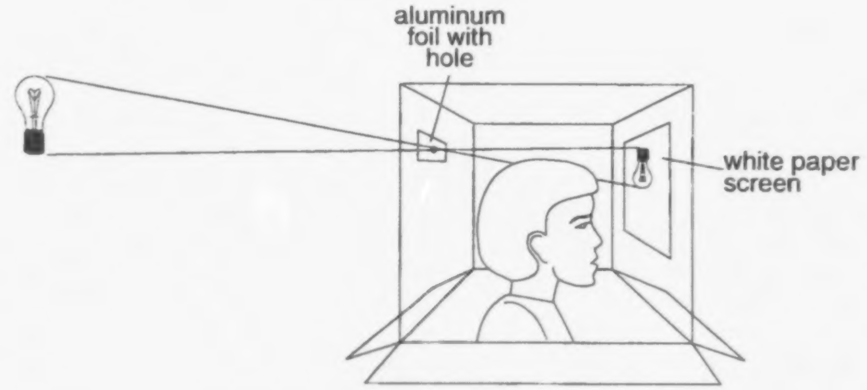
aluminum foil with hole
white paper screen

Figure 5.10.3(1) Simple camera obscura made from a cardboard box. White paper is used as a screen. Light passes through a single small hole in aluminum foil.

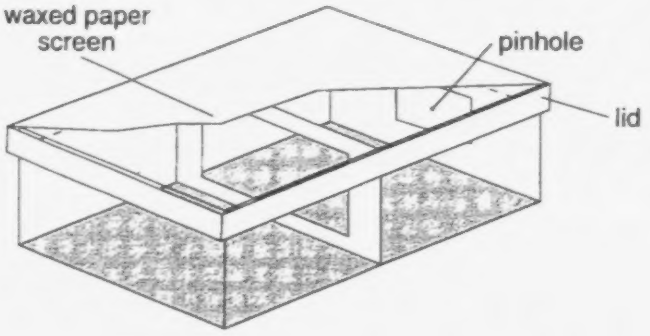
waxed paper screen
pinhole
lid

Figure 5.10.3(2) Back-viewing camera obscura. The waxed paper screen should be shielded from as much light as possible except light from the pinhole.

DASH

Name____________________________

Date____________________________

STUDENT PAGE 5.10.3 CAMERA OBSCURA

1. Draw a camera obscura showing how the light seems to travel through the hole to make an image.

2. Draw your back-viewing camera obscura.

3. Describe how you made the image larger.

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4. Suggest an explanation to account for the upside-down image.

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ACTIVITY 5.10.4
CONTROLLING LIGHT WITH LENSES

OBJECTIVES

The students
- Identify the focal point and the focal length of lenses.
- Observe the pattern light makes when it passes through a lens.
- Observe how to cast images of objects.
- Observe the conditions under which an object is magnified.
- Distinguish between a ray and a beam.
- Contrast the characteristics of light from the sun and light from a bulb.

BACKGROUND

This activity is one of a series on optics. It follows Activity 5.10.3 CAMERA OBSCURA and leads to 5.10.5 MAKING A TELESCOPE and 5.2.8 MOON THROUGH A TELESCOPE. In CONTROLLING LIGHT WITH LENSES the students explore lenses. They will need to work in groups using lenses of different sizes. Because of the richness of the world of lenses, several days may be needed for exploration. Remind the students that in the excitement of finding things, discoveries may be lost unless notes and drawings are made of what is observed.

Approach
Description will be the end point for most students' work even though wonderful mathematical relationships can be derived from these explorations. Encourage mathematical relationships to emerge if the students wish to pursue their ideas.

It is assumed that most teachers will have only convex (bulging outward) lenses available to them. If, however, concave (bulging inward) lenses are available, a parallel study of these lenses will provide some exciting anomalies. The concave studies should be done after the studies with the convex lenses have been completed.

STUDENT ROLE

Physicist

MATERIALS

eyeglass lenses
convex lenses
concave lenses if available
hand lenses
aluminum foil
light bulb and source of electricity
cardboard
flashlight
nails to make holes
comb
Student Page 5.10.4 LENSES

PRODUCTS

Completed Student Pages

PROCEDURES

1. **Have the students explore using hand lenses with the sun as a light source.**

   Have them
   - Explore to find out as many different things as possible the lenses will let them do with sunlight.
   - Record all observations and investigations so they can teach someone else how to get the same results.

2. **Have the students share their findings.**

   Ask such questions as these:
   - Was anyone able to get all of the light to come to a point?
   - Can you teach us how we can get our lenses to bring light to a focal point? (Introduce the term *focal point*. If the lens is focused on the same spot too long, the screen will start to smoke.)
   - Was anyone able to see the light as it came to a point?
   - Can you teach us how we can see light coming to a point? (This may have to be demonstrated by you, but before showing the students, have them again explore. The converging of light can be seen by placing a piece of cardboard within the light beam at a slight tilt to the axis of light traveling through the lens. Use a piece of cardboard with a non-white surface to diminish light glare. See Figure 5.10.4[1].)

- Does light come to the same point each time you look for the focal point? (Yes.)
- How could we define the same point? (Get at the idea of some fixed distance from the lens. Have the students measure the distance between the lens and the focal point and report it on their Student Page 5.10.4 LENSES. This distance is called the focal length. See Figure 5.10.4[2].)
- Do all lenses bring light together at a point at the same distance from the lens? (If lenses of different curvature are used, the focal lengths will be different. Thick lenses will normally have shorter focal lengths than thin lenses of the same diameter.)
- What else were you able to do with the lens using the sun as a light source? (Get at such things as using the lens to burn paper.)
- Can you create a spreading beam of light after the light has converged at the focal point? (This can be done by inserting the slanted cardboard in the beam.)
- Did you observe the rainbow of colors at the point of the converging beam. (The colors result from the prismatic breakup of light by the lens. Have the students teach each other how to see what they saw and how to do what they did. Put any questions in the Wonder and Discover Book.)

3. Have the students explore using hand lenses in a darkened room with an electric light bulb as the light source.

Have them
- Explore to find out as many different things as they can about the lenses and using light from a bulb.
- Record all observations and investigations so they can teach someone else how to get the same results.

4. Have the students share their findings.

Ask such questions as these:
- Was anyone able to get all of the light to come to a point as you did with the sun's light?
- Can you teach us how we can get our lenses to bring light to the focal point? (Light from a naked bulb will not come to a crisp focus. To get all the light to come together at the focal point, the incoming light rays must be parallel. One way of getting nearly parallel light is to place the light source as far away as possible. Light rays from the sun are considered to be parallel. They travel over 93,000,000 miles or 155,000,000 km to us from the sun.)
- Was anyone able to cast an image of the light source on a piece of paper?

- Can you teach us how to cast an image of the bulb on some kind of screen? (Casting an image on a screen can be done by putting a light bulb anyplace beyond the focal point on one side of the lens and then moving the screen until the image is in focus on the other side of the lens.)
- Is the image at the same distance from the lens each time you cast it? (Have the students test their answers, working to agreement that the image will be different distances, depending on how far the light source is from the lens.)
- Was anybody able to cast an image that was larger than the light source?
- Can anyone teach us how we can cast an image that is larger than the light source? (This may have to be demonstrated by you, but before showing the students, have them again explore. The casting of an image larger than the light source can be done by placing the lens more than 1 focal length but less than 2 focal lengths away from the light bulb. The paper screen can then be moved back and forth until an image appears. See Figure 5.10.4[3].)
- Was anybody able to cast an image that was smaller than the light source? (This again may have to be demonstrated by you, but before showing the students, have them again explore. To cast a small image, place the lens farther than 2 focal lengths from the light. The paper screen can then be moved back and forth until an image appears.)
- Can you teach us how we can cast on a screen an image that is smaller than the light source?

5. **Have the students explore how to get images of different sizes.**

Ask such questions as these:

- How can you get the largest possible image? (Have the students explore and share their answers. Help them find that as the lens gets closer to 1 focal length from the light source, the image gets bigger and bigger. See Figure 5.10.4[4]. Have them record their results on Student Page 5.10.4 LENSES.)
- How can you get the smallest possible image? (Have the students explore and share their answers. Moving the lens farther and farther from the light source will make the image smaller and smaller. See Figure 5.10.4[5].)
- How could you cast an image that is the same size as the light source? (Have the students explore and share their answers. Moving the lens to the point 2 focal lengths from the light source will cast an image that is the same size as the light source. See Figure 5.10.4[6].)

6. **Help the students develop a working definition for a beam of light. Produce a beam by turning on a flashlight. Have the students compare this light with that from an electric light bulb.**

   Ask such questions as these:
   - What is the difference between the beam of light and the light from the light bulb? (Get at the idea that in the beam the light is going in one direction while the light bulb throws light in all directions.)
   - What can we use as a working definition for a beam of light? (Work to the idea of a column or stream of light all going in one direction.)

7. **Develop a working definition for a light ray. Demonstrate how to get a simulated ray of light by punching a small hole in a piece of cardboard or using a comb and following a sun ray on a piece of cardboard. See Figure 5.10.4(7).**

   Ask such questions as these:
   - What might be a good working definition of a sun ray? (Work for the idea that it is a thin line of light.)
   - Can anyone simulate a sunbeam? (Get at the idea of making a large hole in cardboard.)
   - How does a sunbeam differ from a sun ray? (Get at the idea that a ray is much smaller.)
   - How can we add to our definition of a light beam using the idea of a ray? (Get at the idea that a light beam can be considered a collection of light rays all going in the same direction.)

8. **Have the students explore how to get a beam of light from a light-bulb source. Have them record all observations and investigations so they can teach someone else how to get the same results.**

9. **Have the students share their findings on creating light beams.**

   Ask such questions as these:
   - Was anyone able to get a beam of light using the light bulb?
   - Can you teach us how you got your beam? (Have the students demonstrate. If the students were unsuccessful, continue with the probing.)

- How might we use a tube to get a beam of light? (Have the students explore and then demonstrate their findings. A light shield with a small tube running through it will cut out almost all the rays of light except those going in the same direction. See Figure 5.10.4[8].)
- How might we use a lens to get a beam of light? (Have the students explore and then demonstrate their findings. If the light source is placed at or very near the focal point of the lens, it will cast a near-parallel beam of light.)

10. **Have the students use a comb or a piece of cardboard with a hole to invent a way to follow rays of light as they pass through their lens.**

Have them

- Demonstrate how their device to observe rays works. (Cardboard with holes can be used along with a cardboard screen. See Figure 5.10.4(9).)
- Modify their devices to make them functional.

11. **Have the students predict the path of the rays in the situations listed below and in any other situations the students may think of on their own. Then have them investigate what happens to the rays as they pass through a lens and describe it on Student Page 5.10.4 LENSES.**

Some suggested situations are

- Light from the sun.
- Light from a light bulb as the lens is moved farther and farther away.
- Light shining through a lens with a light bulb held at different distances from the lens.

12. **Have the students focus a lens on a distant object as they hold the lens at arm's length. Have them slowly move the lens toward their eye and note any changes in their view. See Figure 5.10.4(10).**

Ask such questions as these:

- What did the distant object look like in the beginning? (It was upside down.)
- Was the object clearly seen through the lens? (Usually yes.)
- Was there any change in the view as you got closer to the lens? What was the change? (The object flipped over.)

13. **Have the students hold a lens at arm's length and look at an object at a distance less than one focal length from the lens. Have them slowly move the lens toward the eye and record what they see.**

    Ask such questions as these:
    - What did the object look like in the beginning? (Enlarged.)
    - Was the object clearly seen through the lens? (Usually yes.)
    - Was there any change in the view as the lens got closer to the eye? What was the change? (The object first magnifies then flips over.)
    - At what distance did changes occur? (At about 1 focal length.)

EXTENSIONS

Have the students
- Explore convex lenses on their own and report their findings.
- Run similar explorations with concave lenses.

ILLUSTRATIONS

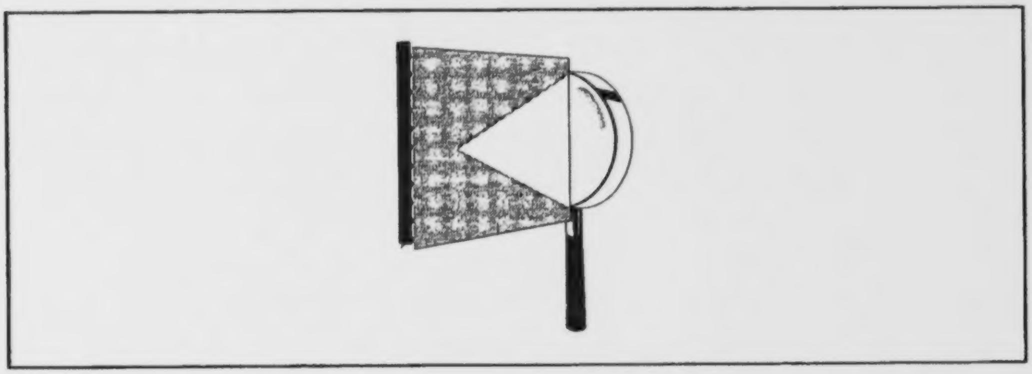

Figure 5.10.4(1) Light from a lens coming to a focal point on a piece of cardboard

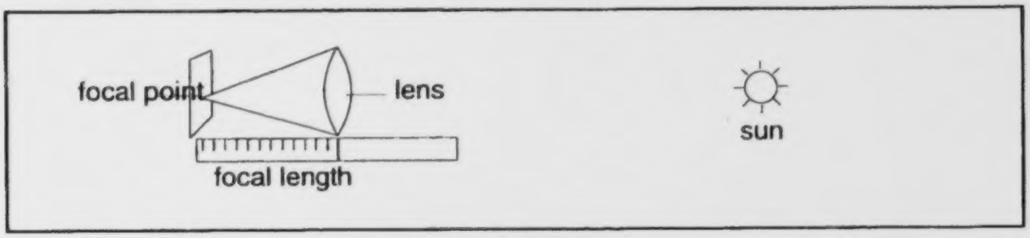

Figure 5.10.4(2) Finding focal length—the distance from the lens to the focal point

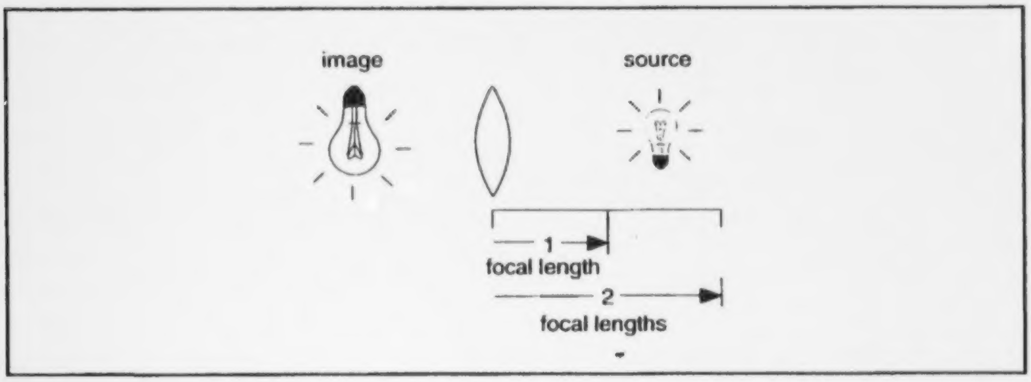
image
source
1
focal length
2
focal lengths

Figure 5.10.4(3) Enlarged image is produced when a source is between 1 and 2 focal lengths from the lens

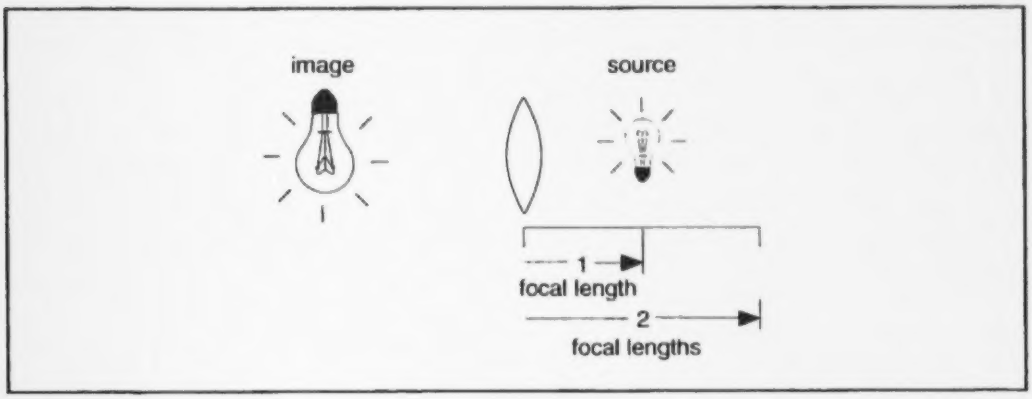
image
source
1
focal length
2
focal lengths

Figure 5.10.4(4) The largest image is produced when the source is almost 1 focal length from the lens

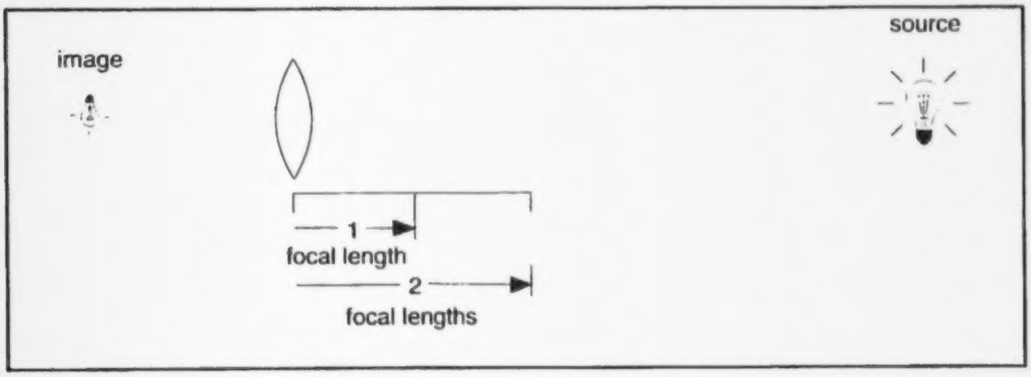
image
source
1
focal length
2
focal lengths

Figure 5.10.4(5) The smallest image is produced when the source is far from the lens

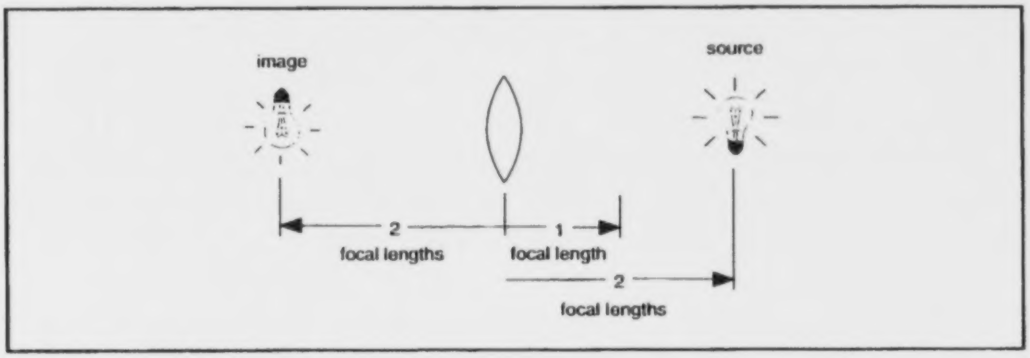
image
source
2
focal lengths
1
focal length
2
focal lengths

Figure 5.10.4(6) An image the same size as the source is produced when the source and the image are 2 focal lengths from the lens

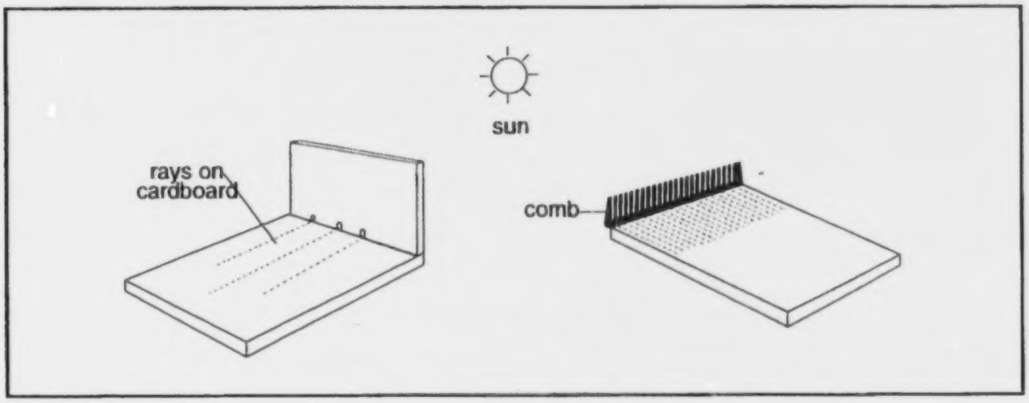
sun
rays on cardboard
comb

Figure 5.10.4(7) Sun rays produced using cardboard with holes and a comb

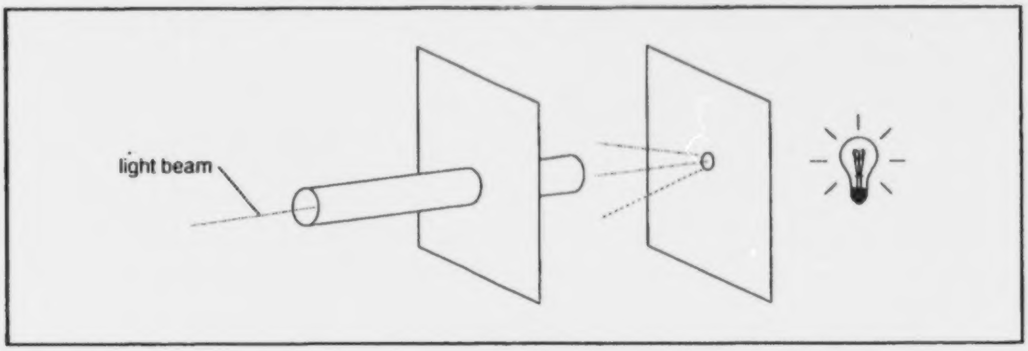

Figure 5.10.4(8) Light from a bulb made into a beam by cutting out all rays except those moving in a straight path

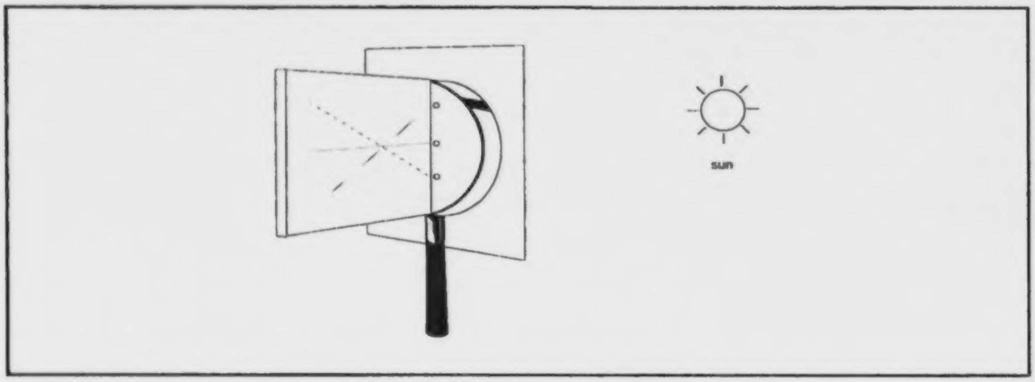

Figure 5.10.4(9) Using 3 rays to analyze the path of light from the sun through a lens

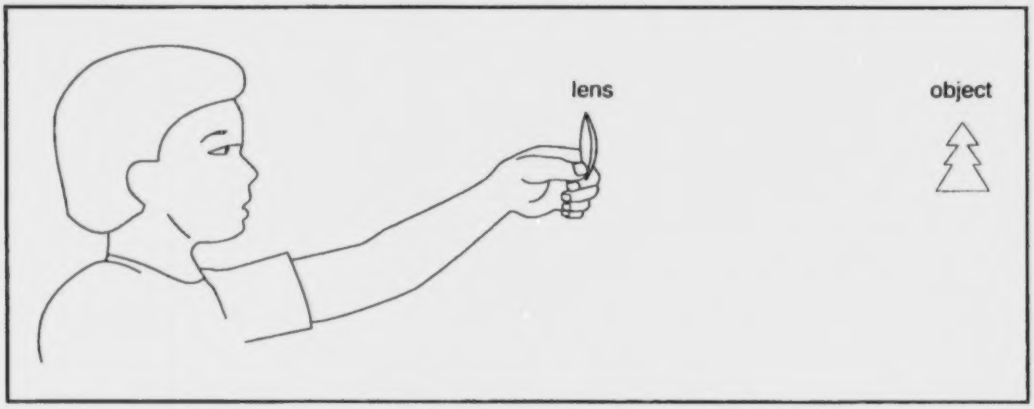

Figure 5.10.4(10) Moving a lens from arm's length toward the eye to view a distant object

Name ____________________

Date ____________________

STUDENT PAGE 5.10.4 LENSES

Complete the following. Use drawings where needed.

1. Record your observations on using a lens with sunlight.

2. Describe the focal point of the lens.

3. Record how far the focal point is from the lens. __________

Name____________________________

4. Draw the path of the sunlight after it passes through a lens.

5. Record your observations using a lens with a light bulb.

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6. Record how far the focal point is from the lens. ____________

7. Describe how the focal point of the bulb light compared with the focal point of the sunlight.

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Name ____________________

8. Describe how you cast an image larger than the light source on a screen.

9. Describe how you cast an image smaller than the light source on a screen.

10. Describe how you placed the lens and the screen in order to cast the largest possible image, the smallest possible image, and an image that was the same size as the light source.

Name____________________________

11. **Record your working definitions of a beam of light and a ray of light.**

12. **Describe how to get a beam of light from a light-bulb source.**

13. **Describe your way to follow rays of light as they pass through a lens.**

Name________________________

14. Describe the path of the rays from the sun.

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15. Describe the path of rays from a light bulb.

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16. Describe how the appearance of the object seen through a lens changes when a) the lens is focused on a distant object and b) the lens is moved toward the eye.

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Name____________________________

17. Describe how the appearance of the object seen through the lens changes when a) the lens is focused on an object close to it and b) the lens is moved toward the eye.

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ACTIVITY 5.10.5 MAKING A TELESCOPE

OBJECTIVES

The students
- Use their knowledge of lenses to build a telescope.
- Invent a way of holding lenses in a tube.
- Invent a way to test the magnifying power of their telescope.

BACKGROUND

This activity is one of a series of activities on optics. Here the students construct their own telescopes by building on what they did in Activities 5.10.3 CAMERA OBSCURA and 5.10.4 CONTROLLING LIGHT WITH LENSES. They then invent a way of determining the magnifying power of their scope. They use their telescopes in Activity 5.2.8 MOON THROUGH A TELESCOPE when they observe the moon.

Image of Objective Lens

In this activity the students determine where the objective lens casts an image and where they must place the eyepiece to get the greatest magnification. Knowing these two things allows them to estimate the length of the telescope barrel.

Telescope Magnification

Magnification can be estimated by looking at distant objects that have divisions of equal distance (slats in a fence, floors in a distant apartment building, and so forth) and counting the number of "lines" seen in the telescope versus the number seen in the same space by the unaided eye. Look at the object through a tube without a lens and count the floors. Look through the tube with the lens. If you see two floors with the telescope and 20 with the unaided eye, the magnification is 10.

STUDENT ROLE

Physicist

MATERIALS

shoe box back-viewing camera obscura from Activity 5.10.3
cardboard shoe boxes
cardboard tubes
Styrofoam pieces to hold lenses
objective lenses (hand lenses or commercial telescope lenses)
eyepiece lenses (hand lenses or commercial telescope lenses)
waxed paper
Student Page 5.10.5 MAKING A TELESCOPE

PRODUCTS

Telescopes
Completed Student Pages

PROCEDURES

1. **Introduce the need to have telescopes that can be used to view the moon. Work through the logic of the lens system of a telescope. See Figure 5.10.5. Have the students work in pairs.**

   Have the students
   - Replace the pinhole in their camera obscura with a lens.
   - Cast an image on the screen of their camera obscura using an object that is across the room or outdoors.
   - Measure the distance from the lens to the screen.
   - Demonstrate that they can focus the image on the screen by moving the screen. As they progress, have them help each other.

2. **Have the students build a telescope.**

   Ask such questions as these:
   - Is the image on the screen right side up, upside down, or some other position? (Have them demonstrate the "upside downness.")
   - What is the size of the image on the screen compared to the source?
   - How could we enlarge the image? (If there is no answer, have the students explore. The students will probably say to bring the object closer.)
   - Could we use another lens to magnify the image? How? (Have the students explore with a second lens.)

- Can anyone show us how to enlarge the image? (Work for agreement that the second lens can be used as a magnifier of the image.)
- Is the image turned right side up or does it stay upside down? (Work for agreement that it stays upside down.)
- What happens to the image on the screen if we move the lens closer to the light source? (It gets out of focus.)
- What would we have to do to get the image back in focus? (Pursue the idea of changing the distance between the screen and the lens.)
- What happens to the image on the screen if we get farther from the source? (It again gets out of focus.)
- What would we have to do to get the image back in focus? (Pursue the idea of changing the location of the screen.)
- How could we hold the second lens in the tube so that it would be in line with the lens already in the box? (Work to the idea of having some sort of extension such as a second box or a tube to hold it.)
- How could we get the second lens to move back and forth? (Make the extension a sliding box or tube.)
- Can anyone remove the screen and make the two lenses into a telescope?

3. **Have the students invent a telescope with a sliding eyepiece and test it on different objects.**

4. **Have the students estimate the amount of magnification.**

Ask such questions as these:

- How much larger does the image you see in the telescope appear than the object being viewed? (Put these estimates on the board. Try to get the students to use such language as “twice as large,” “three times as large,” and so forth.)
- How did you make your estimates?
- Did anyone try looking at an object through a tube that has no lens and comparing this image with what you saw through your telescope? (Have them try this and get an estimate of image magnification.)

EXTENSIONS

Have the students

- Invent a way to quantify the amount of magnification.
- Invent a telescope that turns the image right side up.

ILLUSTRATION

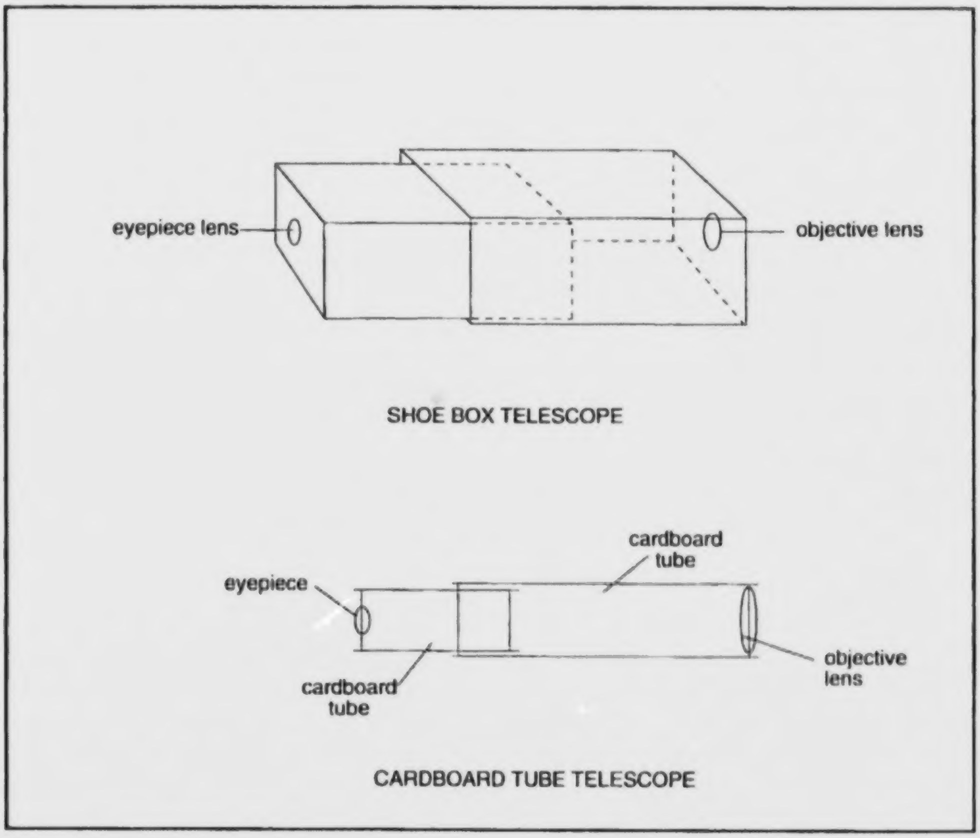
eyepiece lens
objective lens
SHOE BOX TELESCOPE
cardboard tube
eyepiece
objective lens
cardboard tube
CARDBOARD TUBE TELESCOPE

Figure 5.10.5 Prototype telescopes

DASH

Name________________________

Date________________________

STUDENT PAGE 5.10.5 MAKING A TELESCOPE

1. Draw and label a diagram showing how you made a screen-and-lens system out of your camera obscura.

2. Use a diagram to describe the steps you took in making your telescope.

3. Describe how you determined the magnification. Record the magnification.

MAGNIFICATION	

ACTIVITY 5.10.6 STABILIZING THE TELESCOPE

OBJECTIVES

The students
- Invent ways of stabilizing their telescope.

BACKGROUND

This activity should be done along with Activity 5.2.8 MOON THROUGH A TELESCOPE and after Activity 5.10.5 MAKING A TELESCOPE. In STABILIZING THE TELESCOPE the students confront the problem of making their telescope stable enough to observe distant objects. This is an ideal opportunity for invention.

Start with the problem—a scope that jiggles. Have the students invent ways of stabilizing their scope. These might include
- using strong rubber bands to fasten the scope to a stationary object
- placing the scope on a sandbag

STUDENT ROLE

Engineer

MATERIALS

materials as identified by students
telescopes from Activity 5.10.5 MAKING A TELESCOPE
Student Page 5.10.6 STABILIZER

PRODUCTS

Telescope stabilizers
Completed Student Pages

PROCEDURES

1. **Have the students use their telescopes to observe the moon during the day.**

   Ask such questions as these:
   - What does the moon look like through your telescope?
   - Did anyone see craters?
   - Did anyone see dark areas?
   - Did anyone have trouble seeing the moon? (By this time the students will have found that it is very hard to hold their telescopes securely enough to see clearly.)
   - What is the problem? (Get at the idea that the telescopes jiggle so much they can't be focused.)
   - Did anyone solve the problem? If so, how?

2. **Have the students invent and make their own stabilizer. Have them use Student Page 5.10.6 STABILIZER to explain how they stabilized their scopes.**

EXTENSION

- Have the students research the ways commercial telescopes are stabilized.

Name____________________

Date____________________

STUDENT PAGE 5.10.6 STABILIZER

1. Draw your stabilizer.

2. Describe how your stabilizer works.

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ACTIVITY 5.10.7 MAKING A MICROSCOPE

OBJECTIVES

The students
- Make a microscope.

BACKGROUND

This activity is part of the light series. It should follow Activities 5.10.4 CONTROLLING LIGHT WITH LENSES and 5.10.5 MAKING A TELESCOPE and precede Activity 5.3.4 CELLS.

In MAKING A MICROSCOPE the students build a scope to aid their investigation of cells. A relatively simple design is shown in Figure 5.10.7.

STUDENT ROLES

Physicist
Microscope maker

MATERIALS

cardboard soda-can holders
rubber bands (assorted)
clear colorless marbles
magnifying lenses
opaque 35-mm film canisters
caps from 2-liter soda or juice bottles
toilet paper tubes
clear 9-oz plastic cups
plastic soda bottles to make slide strips
serrated knives
masking tape
scissors
Student Page 5.10.7 MICROSCOPE

PRODUCTS

Microscopes
Completed Student Pages

PROCEDURES

1. **Introduce the need to have microscopes that can be used to view the parts of living things. Lead the students through the making of a microscope. See Figure 5.10.7.**

   They will need to
   - Use a transparent plastic cup as a base for the scope.
   - Secure the objective lens in the bottom of the film canister.
   - Mount the eyepiece lens in a toilet-paper tube that will slide over the film canister, holding the objective lens if necessary.
   - Make a plastic specimen holder.

2. **Help the students invent a way to reflect light up through slides or plastic or glass dishes.**

EXTENSION

- Have the students draw the lens system of their microscope.

ILLUSTRATIONS

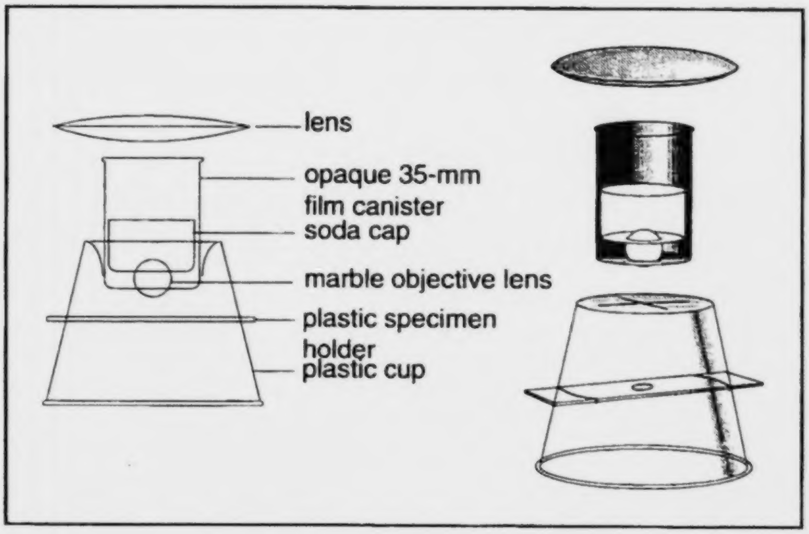
lens
opaque 35-mm film canister
soda cap
marble objective lens
plastic specimen holder
plastic cup

Figure 5.10.7 Design for a simple microscope

DASH

Name________________________

Date_________________________

STUDENT PAGE 5.10.7 MICROSCOPE

1. Make a diagram of your microscope and label the parts.

2. Describe your invention to hold the specimens while you work.

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3. Describe how you are getting light on and below the things you are observing.

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ACTIVITY 5.10.8 MAKING A HYGROMETER

OBJECTIVES

The students
- Make a hygrometer.
- Explain the workings of the hygrometer.
- Make and practice reading a hygrometer.

BACKGROUND

This activity should follow Activity 5.2.1 WEATHER STATION and precede Activity 5.2.2 HEAT INDEX and 5.10.9 MAKING A BAROMETER.

Approach

In Activity 5.10.8 the students make a wet-and-dry-bulb hygrometer to measure relative humidity. They collect data for several days, then analyze it to discover the functions of the wet and dry bulbs. In the analysis the students test the hypotheses that evaporation cools and that more evaporation occurs in dry air than in moist air. The Relative Humidity Tables are introduced and explained, then collection of relative humidity data is begun.

Construction

Because of the expense of glass thermometers it may be advisable to make only two or three hygrometers. This can be done by one group of students while the rest of the class is working on other construction such as making a barometer.

Students are often quite sophisticated in invention; however, devices they construct often work for only a short time. In this activity have them concentrate on building their hygrometers to last for the full school year. For a possible design see Figure 5.10.8. One hygrometer should be permanently situated in the classroom for daily indoor recording and another should be portable for outdoor recording.

Relative Humidity

The students have seen that air can hold water vapor when they have observed mist condensing on a window and moisture from their breath condensing on a cold surface. These are evidences that invisible water vapor exists in air. The higher the temperature, the more water vapor air can hold. We say that air is *saturated* with vapor when it can hold no more water. This means that if the air above a container of water is still and saturated, no more water will evaporate from the container.

The amount of moisture or water vapor in the air is usually reported as relative humidity. *Relative humidity* is a comparison of the amount of water vapor actually in the air at a given temperature compared to the maximum amount of vapor the air can hold at that temperature. It is expressed in a percentage.

A relative humidity of 100% means that the air has all the water vapor it can hold. In still air no more water will evaporate. The air is saturated. If there is no water vapor in the air, the relative humidity is 0%.

The Hygrometer

Relative humidity is measured using a hygrometer. The hygrometer suggested for use here is constructed from two thermometers, a wick, and a holder for water. One thermometer has a wick of water-absorbent cloth wrapped and tied around its bulb. This wick is put into water so that moisture travels up around the bulb. Be sure the bulb is **not** placed in the water. If the bulb is in the water, the thermometer will read the water's temperature rather than the temperature produced by evaporation. The second thermometer should be kept dry. These thermometers are called wet- and dry-bulb thermometers.

Water evaporating from the wick lowers the temperature of the wet-bulb thermometer. Water does not evaporate when the air is completely saturated, and it evaporates at different rates according to the degree of partial saturation. If the air is 80% saturated, much less water will evaporate than when it is 30% saturated. Therefore the cooling of the wet thermometer will be less at 80% saturation than at 30% saturation. Tables of values have been constructed to use in determining relative humidity. They are based on the difference in temperature of the wet- and dry-bulb thermometers.

Standardizing Thermometers

Inexpensive thermometers are seldom standardized. A thermometer can be standardized in the following way:

- Wrap tape around the upper end of the thermometer.
- Make a 0°C ice-and-water mixture by putting crushed ice into a small amount of water.

- Put the thermometer into the ice-and-water mixture. Swirl the mixture with a wooden stick until the temperature stops going down. The mixture will be at 0°C. **Do not** use the thermometers to stir the mixture because they are easily broken.
- When the temperature stops going down, record the temperature registered on the thermometer.
- Determine any change in temperature from 0°C.
- Mark the tape to add the difference if the temperature reading is below 0°C.
- Mark the tape to subtract the difference if the temperature reading is above 0°C.

For example, if a thermometer reads +2°C, write -2°C on the tape because +2 and -2 equal 0 and -2°C corrects the temperature to 0°C. If a thermometer reads -2°C, write +2°C on the tape because -2 and +2 equal 0. In other words, correct the thermometer by adding the correction marked on the tape to the registered temperature or by subtracting the marked correction from it.

Reading the Relative Humidity Table

The Relative Humidity Tables have one column headed *Dry-Bulb Reading* and a series of columns under the major heading *Difference between Dry-Bulb and Wet-Bulb Readings.* The columns under Difference are sub-headed by differences in temperature between the wet- and dry- thermometer readings. Listed beneath the individual differences are the relative humidities. To use the tables find the intersection of the dry-bulb reading and the difference. This will show the relative humidity. See the tables in Student Page 5.10.8A.

Celsius Table

For example, on the Celsius table if the dry-bulb reading is 15°C and the wet-bulb reading is 12°C, the difference between the two readings is 3°C. Moving down the dry-bulb column, we find 15°C and read across to the Difference of 3°C column. At the intersection we find a relative humidity of 71%.

Fahrenheit Table
On the Fahrenheit table if the dry-bulb reading is 50°F and the wet-bulb reading is 40°F, the difference is 10°F, and the relative humidity is 39%. If the dry reading is 66°F and the wet is 60°F, the relative humidity is 71%.

STUDENT ROLES

Meteorologist
Instrument maker

MATERIALS

thermometers
masking tape
stirring stick
cotton cloth
rubber band or string to secure cloth wick
water container
pint jars
rubber foam strips to seal thermometers into jars
cobalt chloride paper (Turn blue by drying on a hot dry surface.)
pan to hold hot water
source of hot water
crushed ice
Student Pages 5.10.8A RELATIVE HUMIDITY TABLES
5.10.8B MAKING A HYGROMETER

PRODUCTS

Hygrometers
Completed Student Pages

PROCEDURES

1. **Lead students through the standardization of a thermometer if necessary.**

2. **Have the students make hygrometers. See Figure 5.10.8.**

Have them
- Demonstrate to the class how the hygrometers were constructed.
- Set up the hygrometers so they are operating.
- Observe the hygrometers and collect data from the wet-and-dry-bulb thermometers mornings and afternoons for several days.

3. **Have the students make a concept map of the term humidity.**

Help them include such things as these:
- The amount of water in air.
- Cobalt chloride paper as an indicator of humidity.
- High humidity.
- Red for moist air.
- Low humidity.
- Blue for dry air.
- Sweat.
- Dry skin.
- Evaporation.

4. **Have the students construct a working definition of humidity and verify it in reference books.**

5. **Analyze the data collected using the hygrometer.**

Ask such questions as these:
- Is there a difference in the readings of the two thermometers? What is it? (If the system is working, the wet-bulb thermometer will read lower than the dry-bulb.)
- What could account for this difference? (Work for the idea that water must be evaporating and cooling the thermometer. If this idea is not offered, have the students wet one index finger and keep one dry. After a minute or so ask whether there is any apparent difference in temperature? The usual feeling will be one of greater coolness on the wet finger.)
- What must have occurred to produce the cooling? (Get at the idea that some of the water on our finger evaporated cooling it.)
- Have we seen this occur before? (Help the students recall that when we dealt with wind chill, we found that evaporation cooled our skin. Relate this to other connections the students may report.)
- How can evaporation be related to humidity? (Record students' hypotheses.)

6. **Introduce the Relative Humidity Tables and explain how to read them.**

EXTENSION

- Have students investigate how the United States Weather Service collects data on relative humidity.

ILLUSTRATION

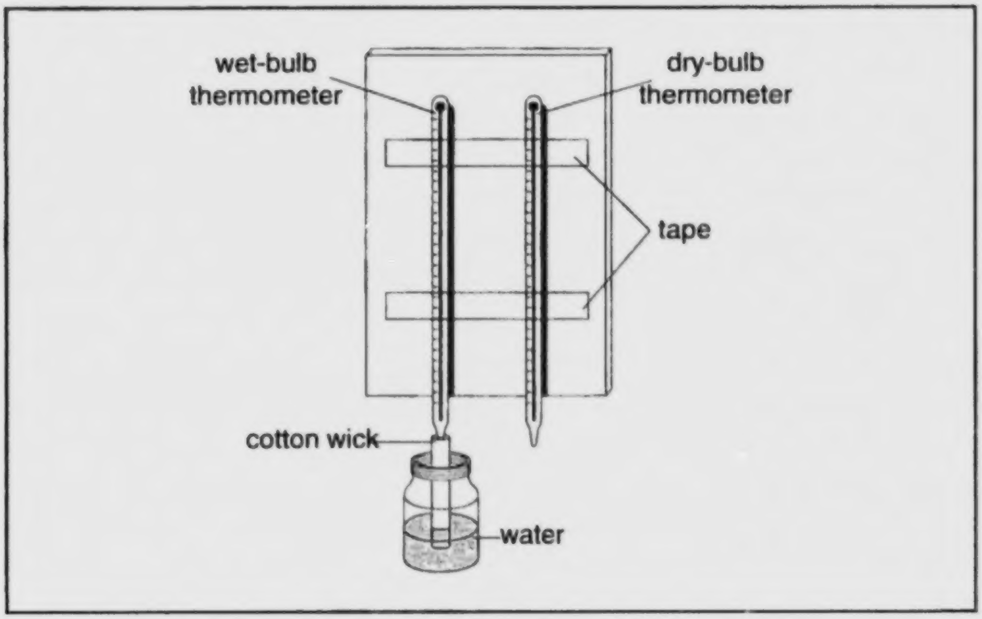
wet-bulb thermometer
dry-bulb thermometer
tape
cotton wick
water

Figure 5.10.8 Design for a simple hygrometer

DASH

Name____________________________

Date____________________________

STUDENT PAGE 5.10.8A RELATIVE HUMIDITY TABLES

RELATIVE HUMIDITY TABLE FOR FAHRENHEIT READINGS

Dry-Bulb Reading (°F)	Difference between Dry-Bulb and Wet-Bulb Readings in °F																	
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
50	93	87	80	74	67	61	55	50	44	38	33	27	22	16	11	6	1	0
52	94	87	81	75	69	63	57	51	46	40	35	30	24	20	15	10	5	0
54	94	88	82	76	70	64	59	53	48	43	38	32	28	23	18	13	8	4
56	94	88	82	77	71	65	60	55	50	44	40	35	30	25	21	16	12	8
58	94	89	83	78	72	67	61	56	51	46	42	37	33	28	24	19	15	11
60	94	89	84	78	73	68	63	58	53	48	44	39	34	30	26	22	18	14
62	95	89	84	79	74	69	64	59	54	50	45	41	37	32	28	24	20	16
64	95	90	85	79	74	70	65	60	56	51	47	43	38	34	30	27	23	19
66	95	90	85	80	75	71	66	61	57	53	49	45	40	36	32	29	25	22
68	95	90	85	81	76	71	67	63	58	54	50	46	42	38	34	31	27	24
70	95	90	86	81	77	72	68	64	60	55	52	48	44	40	36	33	29	26
72	95	91	86	82	77	73	69	65	61	57	53	49	45	42	38	35	31	28
74	95	91	86	82	78	74	70	66	62	58	54	50	47	43	40	36	33	30
76	95	91	87	82	78	74	70	66	63	59	55	52	48	45	41	38	35	31
78	96	91	87	83	79	75	71	67	63	60	56	53	49	46	43	39	36	33
80	96	92	87	83	79	75	72	68	64	61	57	54	51	47	44	41	38	35
82	96	92	88	84	80	76	72	69	65	62	58	55	52	48	45	42	39	36
84	96	92	88	84	80	77	73	69	66	63	59	56	53	49	46	44	41	38
86	96	92	88	84	81	77	73	70	67	63	60	57	54	51	48	45	42	39
88	96	92	88	85	81	77	74	71	67	64	61	58	55	52	49	46	43	40
90	96	92	88	85	81	78	75	71	68	65	62	59	56	53	50	47	44	41
92	96	92	89	85	82	78	75	72	69	65	62	59	56	54	51	48	45	43
94	96	93	89	86	82	79	75	72	69	66	63	60	57	54	52	49	46	44
96	96	93	89	86	82	79	76	73	70	67	64	61	58	55	53	50	47	45

Figure SP 5.10.8A(1) Relative humidity table for Fahrenheit readings

BEST COPY AVAILABLE

Name______________________________

RELATIVE HUMIDITY TABLE FOR CELSIUS READINGS

Dry-Bulb Reading (°C)	Difference between Dry-Bulb and Wet-Bulb Readings in °C																	
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
0	81	64	46	29	13													
1	83	66	49	33	17													
2	84	68	52	37	22													
3	84	70	55	40	26	12												
4	85	71	57	43	29	16												
5	86	72	58	45	33	20	7											
6	86	73	60	48	35	24	11											
7	87	74	62	50	38	26	15											
8	87	75	63	51	40	39	19	8										
9	88	76	64	53	42	32	22	12										
10	88	77	66	55	44	34	24	15	6									
11	89	78	67	56	46	36	27	18	9									
12	89	78	68	58	48	39	29	21	12									
13	89	79	69	59	50	41	32	23	15									
14	90	79	70	60	51	42	34	26	18	10								
15	90	80	71	61	53	44	36	27	20	13	6							
16	90	81	71	63	54	46	38	30	23	15	8							
17	90	81	72	64	55	47	40	32	25	18	11							
18	91	82	73	65	57	49	41	34	27	20	14	7						
19	91	82	74	65	58	50	43	36	29	22	16	10						
20	91	83	74	66	59	51	44	37	31	24	18	12						
21	91	83	75	67	60	53	46	39	32	26	20	14	9					
22	92	83	76	68	61	54	47	40	34	28	22	17	11	6				
23	92	84	76	69	62	55	48	42	36	30	24	19	13	8				
24	92	84	77	69	62	56	49	43	37	31	26	20	15	10	5			
26	92	85	78	71	64	58	51	46	40	34	29	24	19	14	10			
28	93	85	78	72	65	59	53	48	42	37	32	27	22	18	13	9		
30	93	86	79	73	67	61	55	50	44	39	35	30	25	21	17	13	9	
32	93	86	80	74	68	62	57	51	46	41	37	32	28	24	20	16	12	9
34	93	87	81	75	69	63	58	53	48	43	39	35	30	26	23	19	15	12
36	94	87	81	75	70	64	58	54	50	45	41	37	33	29	25	21	18	15
38	94	88	82	76	71	66	61	56	51	47	43	39	35	31	27	24	20	17
40	94	88	82	77	72	67	62	57	53	48	44	40	36	33	29	26	23	20

Figure SP 5.10.8A(2) Relative humidity table for Celsius readings

DASH

Name ____________________

Date ____________________

STUDENT PAGE 5.10.8B MAKING A HYGROMETER

1. Describe any evidence indicating a temperature change when moisture evaporates from a surface.

2. Explain how your hygrometer works.

ACTIVITY 5.10.9 MAKING A BAROMETER

OBJECTIVES

The students

- Explore the meaning of high and low pressure using a balloon-and-bottle system.
- Make and standardize barometers.
- Start recording high and low barometric readings on the Learning Calendar.

BACKGROUND

This activity should be done along with Activity 5.2.3 WEATHER AND ITS PREDICTION. The barometer made in Activity 5.10.9 provides information for the study of general weather patterns and the details of weather fronts.

Mercury Barometers

Barometers are used to measure changes in air pressure. Air pressure is reported in several units. Classically it is reported in centimeters or inches of mercury. Average sea-level air pressure is 76 cm or 30 inches of mercury. This means that on an average day the air above us pushes mercury 76 cm up into the evacuated glass tube of the barometer. Any reading below 76 cm we consider a *low* reading. Anything above 76 centimeters we call a *high* reading. See Figure 5.10.9(1).

Demonstration

To demonstrate what a barometer measures and how it works, have the students fill a balloon with just enough air to give it shape. Have them tie the end of the balloon so that the air cannot escape and then place the balloon in a clear-glass 12-oz juice bottle. Challenge them to shrink the balloon using air alone. They can use their mouth to act as a pressure or vacuum pump. If they put their mouth over the open end of the bottle and force air into it, the balloon will shrink. They will have created a *high-pressure* region around the balloon.

Next challenge the students to expand the balloon, again using only air. They can do this by pulling air from the bottle with their mouth. They will have created a *low-pressure* region around the balloon.

A wonderful anomaly develops when a light-plastic soda bottle is substituted for the glass container. The system will work to shrink the balloon under pressure, but the bottle will collapse instead of the balloon as air is withdrawn. This helps demonstrate that atmospheric air is pushing on the bottle.

Tin-Can Barometer

The tin-can barometer the students make will work the same way the balloon in the bottle did. The barometer should have a flexible diaphragm. This can be made of light, non-porous (non-breathing) plastic wrap or a piece from a large rubber balloon. The diaphragm should not be stretched too tightly. In the middle of the diaphragm a long skewer can be attached to the plastic by tape. The diaphragm will seal air in the tin can.

When the air pressure outside is higher than the pressure inside the can, the diaphragm will be pushed in and the skewer will move up. When the pressure on the outside of the can is lower than the pressure on the inside, the diaphragm will push up and the skewer will move down. See Figure 5.10.11(2). You may want to have a prototype barometer made ahead of time.

After the barometer has been tested, the rim of the can lid can be sealed using plastic sealant. This will further help prevent the loss or entry of air. Having the students use cans of different sizes will give an interesting exploration of movement of the skewer.

Standardizing Barometers

Standardizing the barometer can be done by phoning the local office of the U.S. National Weather Service and asking whether the barometric pressure is high, low, or normal. Build barometers on a day when the service says the pressure is normal. Air in the can on this day can be considered to be captured normal air. Any reading greater than this is a high; anything lower, a low. This simple three-point differentiation is enough for our work and will not exceed the limits of the instrument. Encourage interested students to further refine the scale.

Replacing Barometer

The barometer diaphragm should be replaced periodically. Before the old barometer wears out, build a new one and standardize it with the older version. It may be helpful to find students who like instrument making and have them handle the problem of regular replacement.

STUDENT ROLES

Meteorologist
Instrument maker

MATERIALS

wide-mouthed 12-oz glass juice bottles
12-oz or larger plastic soda bottles
small balloons
tin cans with plastic lids
plastic wrap (non-breathing) or rubber sheeting from a large balloon or surgical glove
plastic sealant
skewers
plastic tape
Student Pages 5.10.9 MAKING A BAROMETER.

PRODUCTS

Completed Student Pages

PROCEDURES

1. **After the students have noted that weather maps show high- and low-pressure areas, try to get a sense of their understanding of the terms.**

   Ask such questions as these:
   - Has anyone seen the terms "high" and "low" on weather maps or heard weather broadcasters refer to them on TV? What do we mean by a high? (Probe for such ideas as it is a high-pressure area or the air above us is pushing down on us more than average. Don't go beyond the students' existing knowledge.)
   - What do we mean by an atmospheric low? (Probe for such ideas as it is a low-pressure area, and the air above us is pushing down on us less than average. Again, don't go beyond the students' existing knowledge.)

2. **Have the students explore making a balloon-in-a-bottle system. Place a slightly filled balloon in a bottle and give them the following challenges.**

- **Challenge 1.** With air alone can you cause the balloon in a glass bottle to shrink? (Have the students explore and demonstrate their results.)
- **Challenge 2.** With air alone can you cause the balloon in a glass bottle to expand? (Have the students explore and demonstrate their results.)
- **Challenge 3.** With air alone can you cause the balloon in a plastic bottle to shrink? (Have the students explore and demonstrate their results.)
- **Challenge 4.** With air alone can you cause the balloon in a plastic bottle to expand? (Have the students explore and demonstrate their results.)
- Have the students explore their own problems.

3. Discuss the explorations.

Ask such questions as these:

- What did you have to do to get the balloon to shrink?
- What did you have to do to get the balloon to expand?
- What was the difference between using a glass container and a plastic container? (Work for agreement that the glass container did not collapse when the air was withdrawn, but the plastic container did.)
- How might we explain the difference between the response of the balloon in the plastic and glass bottles when we withdrew air? (Work for the idea that the because the plastic bottle collapsed, it appears that something was pushing on it. This “something” seems to be air pressure.)
- Which of our challenges produces a high-pressure area? (Probe for the one where air is pushed into the bottle.)
- Which of our challenges produces a low-pressure area? (Probe for the one where air is pulled out of the bottle.)
- What else did you find?

4. Show a prototype for a barometer and have the students work in groups to make their own.

5. Have the students use U.S. National Weather Service information on highs and lows to check high and low pressure on their barometers for a week.

- Check to be sure that instruments are not leaking and are registering changes.

- At the end of the week select a class standard barometer and seal it permanently.
- Periodically replace the existing barometer with a new one standardized using information from the U.S. National Weather Service.

6. **Have the students begin recording barometer readings on the Learning Calendar.**

EXTENSION

- Have a group of students further refine the readings on their barometer.

ILLUSTRATIONS

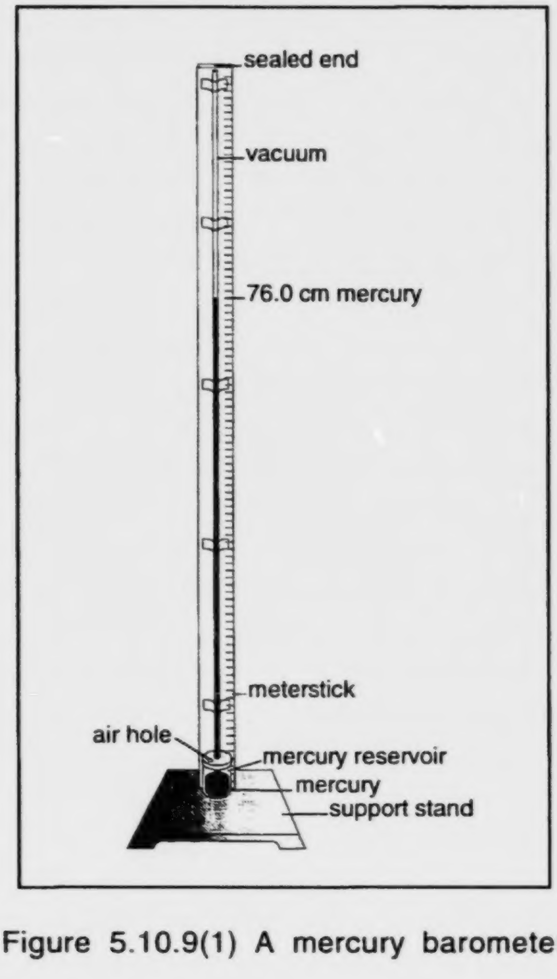
sealed end
vacuum
76.0 cm mercury
meterstick
air hole
mercury reservoir
mercury
support stand

Figure 5.10.9(1) A mercury barometer

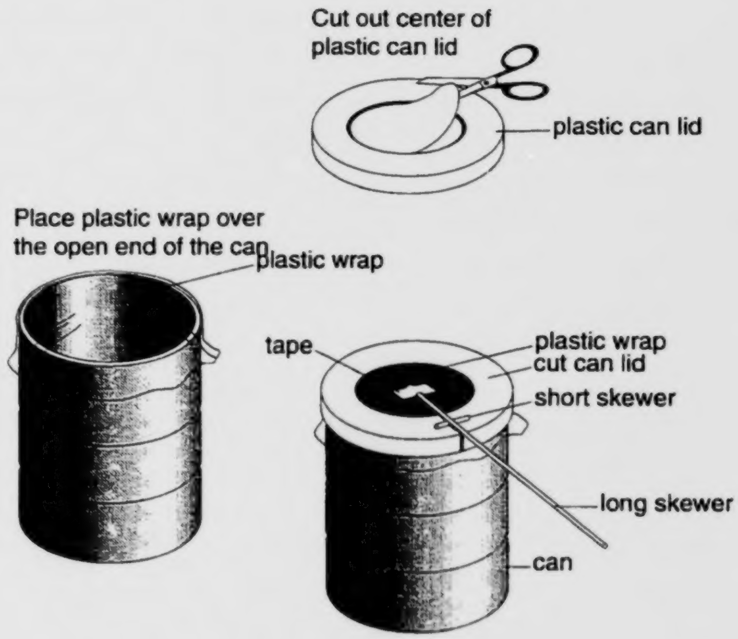
Cut out center of
plastic can lid
plastic can lid
Place plastic wrap over
the open end of the can
plastic wrap
tape
plastic wrap
cut can lid
short skewer
long skewer
can

Figure 5.10.9(2) A tin-can barometer

DASH

Name________________________

Date_________________________

STUDENT PAGE 5.10.9 MAKING A BAROMETER

1. Make a drawing of your barometer.

2. Explain how your barometer works.

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DASH

Name________________________

Date ________________________

STUDENT PAGE 5.10.1A
THE METRIC SYSTEM AND LINEAR MEASUREMENT

Paris, France, 1791. King Louis XVI and Queen Marie Antoinette have been removed from power, and a revolutionary council governs the country. It is a time of social upheaval. Yet it is the time when a report of great historic importance is made by members of the Paris Academy of Science to the French National Assembly. The subject of their report is a system of weights and measures that will become known as the *metric system.*

This report calls for a system to be built around the measurement of the distance between the North Pole and the equator. The standard of distance, called the "meter," is to be one ten-millionth (1/10,000,000) part of that distance. The idea is accepted, and the distance is measured using the most advanced techniques of the day. A platinum bar is carefully marked to preserve this length. This original standard will be very close in length to the modern meter.

Eighty-four years later in 1875 the metric system becomes the international system for scientific measurement. A replica of 1/40,000,000 the distance from the North Pole to the equator appears in Figure SP 5.10.1A.

The Dollar and the Meter

The metric system uses units that are multiples of tens and tenths just like our U.S. system of money. A meter, like the dollar, is the basic unit. The decimeter is like our dime. It is one-tenth of the meter. The centimeter is one-hundredth of a meter. It is like our cent or penny, and the millimeter is one-thousandth of a meter and is like our mill. The mill is one-tenth of a cent and is a money unit sometimes used in taxing property.

Name ________________________

Table SP 5.10.1-1 The metric system and U.S. units of money

Metric Distance	Parts of a Meter	Money	Parts of a Dollar
millimeter (mm)	1/1000	mill	1/1000
centimeter (cm)	1/100	cent	1/100
decimeter (dm)	1/10	dime	1/10
meter (m)	1	dollar	1
kilometer (km)	1000		

U.S. System of Linear Measurement

The U.S. system for measuring distance came from Britain, and this is where it gets the name “British” or “English” system. Its yard, foot, and inch are very old measures. Originally, a yard measured the distance from the tip of the nose to the tip of the fingers on an extended arm. A yard was convenient for measuring cloth. The length of the foot was originally a measure from heel to big toe.

In the United States these measurements were standardized in 1893. At that time a copy of the international meter and the standard yard was set at 0.91 of a meter.

Table SP 5.10.1-2 Metric and U.S. linear units

Metric System		U.S. System
centimeter	=	0.39 inches
inch	=	2.54 centimeter
meter	=	39.37 inches
kilometer	=	0.62 miles

Name ______________________________

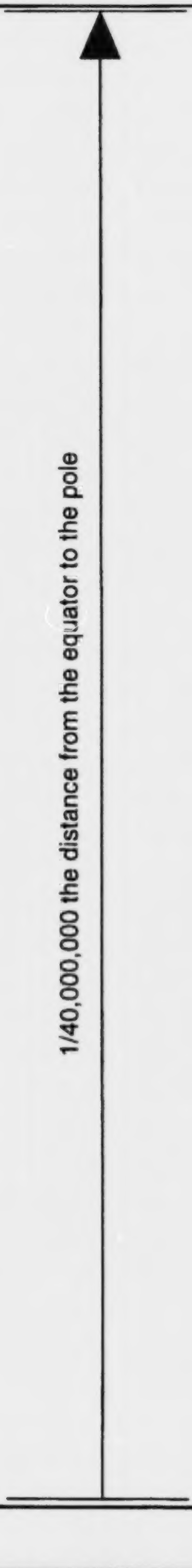
1/40,000,000 the distance from the equator to the pole

Figure SP 5.10.1A Line 1/40,000,000 the standard measurement of the distance from the equator to the poles

Name________________________

Date________________________

STUDENT PAGE 5.10.1B LINEAR MEASUREMENT

1. List advantages of the metric linear measurement system over the U.S. system.

2. List advantages of the U.S. linear measurement system over the metric system.

DASH

Name________________________

Date________________________

STUDENT PAGE 5.10.2A
THE METRIC SYSTEM AND VOLUME MEASUREMENT

The *volume* of a thing is the space that it fits into or occupies. In the measurement of volume we determine how many cubes of some size can fit into the space the object occupies. The cube we use in the metric system is the cubic centimeter (cm^3 or cc). Each edge of this cube is 1 centimeter long.

Measuring the Volume of Boxes

It is easy to measure the volume of a box by using a piece of grid paper marked off in centimeter squares to tell us how many centimeter cubes will fit on the bottom of the box. Then we find out how many layers of these cubes it will take to fill the box. This we can find by using a ruler to measure how many centimeters there are from bottom to top. See Figure SP 5.10.2A. In the examples Box A has 8 centimeter cubes (2 layers of 4 cubes), Box B has 9 centimeter cubes (3 layers of 3 cubes), and Box C has 12 centimeter cubes (3 layers of 4 cubes).

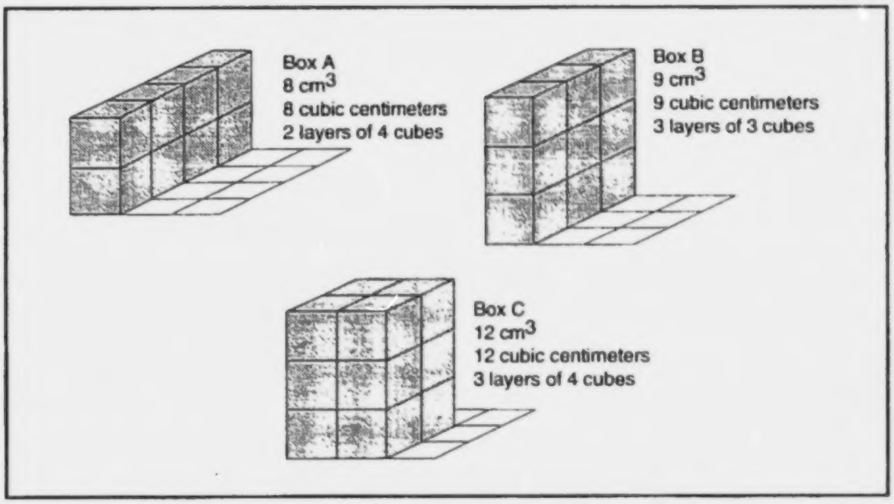
Box A
8 cm^3
8 cubic centimeters
2 layers of 4 cubes
Box B
9 cm^3
9 cubic centimeters
3 layers of 3 cubes
Box C
12 cm^3
12 cubic centimeters
3 layers of 4 cubes

Figure SP 5.10.2A Boxes with volumes of 8, 9, and 12 cubic centimeters

Name______________________________

Calculating Volume

We could arrive at the same answer by multiplying the number of centimeters along the length of the bottom of the box times the number along the width of the bottom times the number making up the height of the box.

Volume of Liquids

The common metric units used to report the volume of liquids are the milliliter (mL) and the liter (L). A milliliter is equal to 1 cubic centimeter, and a liter is equal to 1000 cubic centimeters.

The U.S. System of Volume Measurement

Volume measurement in the U.S. system is done the same way it is in the metric system. Common units of volume are the cubic inch (in^3) and the cubic foot (ft^3).

The U.S. units used to report the volume of liquids are the gallon, quart, pint, cup, and tablespoon. These units are often found in cooking.

Table SP 5.10.2A-1 U.S. liquid units

Unit	Equivalent
gallon (gal)	4 quarts
quart (qt)	2 pints
pint (pt)	2 cups
cup	16 tablespoons

Table SP 5.10.2A-2 Metric and U.S. volume measurements

U.S. Unit	Metric Equivalent
1 cubic inch	about 16 cubic centimeters
1 quart	about 1 liter

Name________________________

Date________________________

DASH

STUDENT PAGE 5.10.2B VOLUME MEASUREMENT

1. Describe how you used a milk carton to measure out 400 mL of water.

2. Describe how you calibrated your large container in 50-mL intervals.

3. Describe how you calibrated the first 50-mL interval in 10-mL intervals.

4. Describe how you calibrated your 20-mL graduated cylinder in 2-mL intervals.

Name____________________

Date____________________

STUDENT PAGE 5.10.3 CAMERA OBSCURA

1. Draw a camera obscura showing how the light seems to travel through the hole to make an image.

2. Draw your back-viewing camera obscura.

3. Describe how you made the image larger.

4. Suggest an explanation to account for the upside-down image.

Name________________________

Date________________________

STUDENT PAGE 5.10.4 LENSES

Complete the following. Use drawings where needed.

1. Record your observations on using a lens with sunlight.

2. Describe the focal point of the lens.

3. Record how far the focal point is from the lens. __________

Name______________________________

4. Draw the path of the sunlight after it passes through a lens.

5. Record your observations using a lens with a light bulb.

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6. Record how far the focal point is from the lens. ____________

7. Describe how the focal point of the bulb light compared with the focal point of the sunlight.

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Name______________________________

8. Describe how you cast an image larger than the light source on a screen.

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9. Describe how you cast an image smaller than the light source on a screen.

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10. Describe how you placed the lens and the screen in order to cast the largest possible image, the smallest possible image, and an image that was the same size as the light source.

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Name______________________________

11. Record your working definitions of a beam of light and a ray of light.

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12. Describe how to get a beam of light from a light-bulb source.

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13. Describe your way to follow rays of light as they pass through a lens.

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Name____________________________

14. Describe the path of the rays from the sun.

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15. Describe the path of rays from a light bulb.

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16. Describe how the appearance of the object seen through a lens changes when a) the lens is focused on a distant object and b) the lens is moved toward the eye.

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Name____________________________

17. **Describe how the appearance of the object seen through the lens changes when a) the lens is focused on an object close to it and b) the lens is moved toward the eye.**

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DASH

Name________________________

Date________________________

STUDENT PAGE 5.10.5 MAKING A TELESCOPE

1. **Draw and label a diagram showing how you made a screen-and-lens system out of your camera obscura.**

2. **Use a diagram to describe the steps you took in making your telescope.**

3. **Describe how you determined the magnification. Record the magnification.**

MAGNIFICATION	

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DASH

Name________________________

Date________________________

STUDENT PAGE 5.10.6 STABILIZER

1. Draw your stabilizer.

2. Describe how your stabilizer works.

DASH

Name____________________

Date____________________

STUDENT PAGE 5.10.7 MICROSCOPE

1. Make a diagram of your microscope and label the parts.

2. Describe your invention to hold the specimens while you work.

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3. Describe how you are getting light on and below the things you are observing.

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Name________________________

Date________________________

STUDENT PAGE 5.10.8A RELATIVE HUMIDITY TABLES

RELATIVE HUMIDITY TABLE FOR FAHRENHEIT READINGS

Dry-Bulb Reading (°F)	Difference between Dry-Bulb and Wet-Bulb Readings in °F																	
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
50	93	87	80	74	67	61	55	50	44	38	33	27	22	16	11	6	1	0
52	94	87	81	75	69	63	57	51	46	40	35	30	24	20	15	10	5	0
54	94	88	82	76	70	64	59	53	48	43	38	32	28	23	18	13	8	4
56	94	88	82	77	71	65	60	55	50	44	40	35	30	25	21	16	12	8
58	94	89	83	78	72	67	61	56	51	46	42	37	33	28	24	19	15	11
60	94	89	84	78	73	68	63	58	53	48	44	39	34	30	26	22	18	14
62	95	89	84	79	74	69	64	59	54	50	45	41	37	32	28	24	20	16
64	95	90	85	79	74	70	65	60	56	51	47	43	38	34	30	27	23	19
66	95	90	85	80	75	71	66	61	57	53	49	45	40	36	32	29	25	22
68	95	90	85	81	76	71	67	63	58	54	50	46	42	38	34	31	27	24
70	95	90	86	81	77	72	68	64	60	55	52	48	44	40	36	33	29	26
72	95	91	86	82	77	73	69	65	61	57	53	49	45	42	38	35	31	28
74	95	91	86	82	78	74	70	66	62	58	54	50	47	43	40	36	33	30
76	95	91	87	82	78	74	70	66	63	59	55	52	48	45	41	38	35	31
78	96	91	87	83	79	75	71	67	63	60	56	53	49	46	43	39	36	33
80	96	92	87	83	79	75	72	68	64	61	57	54	51	47	44	41	38	35
82	96	92	88	84	80	76	72	69	65	62	58	55	52	48	45	42	39	36
84	96	92	88	84	80	77	73	69	66	63	59	56	53	49	46	44	41	38
86	96	92	88	84	81	77	73	70	67	63	60	57	54	51	48	45	42	39
88	96	92	88	85	81	77	74	71	67	64	61	58	55	52	49	46	43	40
90	96	92	88	85	81	78	75	71	68	65	62	59	56	53	50	47	44	41
92	96	92	89	85	82	78	75	72	69	65	62	59	56	54	51	48	45	43
94	96	93	89	86	82	79	75	72	69	66	63	60	57	54	52	49	46	44
96	96	93	89	86	82	79	76	73	70	67	64	61	58	55	53	50	47	45

Figure SP 5.10.8A(1) Relative humidity table for Fahrenheit readings

Name______________________________

RELATIVE HUMIDITY TABLE FOR CELSIUS READINGS

Dry-Bulb Reading (°C)	Difference between Dry-Bulb and Wet-Bulb Readings in °C																	
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
0	81	64	46	29	13													
1	83	66	49	33	17													
2	84	68	52	37	22													
3	84	70	55	40	26	12												
4	85	71	57	43	29	16												
5	86	72	58	45	33	20	7											
6	86	73	60	48	35	24	11											
7	87	74	62	50	38	26	15											
8	87	75	63	51	40	39	19	8										
9	88	76	64	53	42	32	22	12										
10	88	77	66	55	44	34	24	15	6									
11	89	78	67	56	46	36	27	18	9									
12	89	78	68	58	48	39	29	21	12									
13	89	79	69	59	50	41	32	23	15									
14	90	79	70	60	51	42	34	26	18	10								
15	90	80	71	61	53	44	36	27	20	13	6							
16	90	81	71	63	54	46	38	30	23	15	8							
17	90	81	72	64	55	47	40	32	25	18	11							
18	91	82	73	65	57	49	41	34	27	20	14	7						
19	91	82	74	65	58	50	43	36	29	22	16	10						
20	91	83	74	66	59	51	44	37	31	24	18	12						
21	91	83	75	67	60	53	46	39	32	26	20	14	9					
22	92	83	76	68	61	54	47	40	34	28	22	17	11	6				
23	92	84	76	69	62	55	48	42	36	30	24	19	13	8				
24	92	84	77	69	62	56	49	43	37	31	26	20	15	10	5			
26	92	85	78	71	64	58	51	46	40	34	29	24	19	14	10			
28	93	85	78	72	65	59	53	48	42	37	32	27	22	18	13	9		
30	93	86	79	73	67	61	55	50	44	39	35	30	25	21	17	13	9	
32	93	86	80	74	68	62	57	51	46	41	37	32	28	24	20	16	12	9
34	93	87	81	75	69	63	58	53	48	43	39	35	30	26	23	19	15	12
36	94	87	81	75	70	64	58	54	50	45	41	37	33	29	25	21	18	15
38	94	88	82	76	71	66	61	56	51	47	43	39	35	31	27	24	20	17
40	94	88	82	77	72	67	62	57	53	48	44	40	36	33	29	26	23	20

Figure SP 5.10.8A(2) Relative humidity table for Celsius readings

Name ____________________

Date____________________

DASH

STUDENT PAGE 5.10.8B MAKING A HYGROMETER

1. Describe any evidence indicating a temperature change when moisture evaporates from a surface.

2. Explain how your hygrometer works.

DASH

Name______________________

Date______________________

STUDENT PAGE 5.10.9 MAKING A BAROMETER

1. Make a drawing of your barometer.

2. Explain how your barometer works.

DASH 5

ACTIVITY PLANS

Grade 5 DASH: Suggested Year 1 Activity Plan										
CLUSTER	**AUG**	**SEPT**	**OCT**	**NOV**	**DEC**	**JAN**	**FEB**	**MARCH**	**APRIL**	**MAY**	**JUNE**
1. Learning	5.1.1 5.1.2	5.1.1 5.1.2 5.1.3	5.1.1 5.1.2 5.1.3	5.1.1 5.1.2 5.1.3	5.1.1 5.1.2 5.1.3	5.1.1,5.1.2 5.1.3 5.1.6 (5.1.9)	5.1.1 5.1.2 5.1.3	5.1.1 5.1.2 5.1.3	5.1.1 5.1.2 5.1.3	5.1.1 5.1.2 5.1.3	5.1.1,5.1.2 5.1.3 5.1.6 5.1.9
2 Time, Weather & Sky	5.2.1	5.2.1 5.2.2 5.2.3 5.2.4	5.2.5 5.2.6								
3. Animals	5.3.1	5.3.10	5.3.10 (5.3.13)	5.3.10	5.3.10	5.3.10	5.3.10 5.3.13	5.3.10	5.3.10	5.3.10 5.3.6 5.3.7	
4. Plants		5.4.4		5.4.4	5.4.2		5.4.4		5.4.1 5.4.3 5.4.4		
5. Food & Nutrition					5.5.3						
6. Health & Safety	5.6.1		5.6.3 5.6.4				5.6.2				5.6.1
7. Way-finding						5.7.2 5.7.3 5.7.4					
8. Energy & Communication							5.8.1 5.8.2 5.8.3 (5.8.4,5.8.5)	5.8.4 5.8.5 5.8.9			
9. Conserv., Recycling & Decomp.			5.9.3			(5.9.1)			(5.9.3)	5.9.3	
10. Matter, Space & Construct.		5.10.8		5.10.1 5.10.2							
NOTES and ORGANIZING IDEAS	Learning Calendar Records Start-Up	Weather	Safety	Measurement	Food	Astronomy	Forces Mass	Forces Project	Plants	Embryology Male/Fem Urogenital System	

Parentheses indicate optional activities.

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DASH Activities School Year Planning Form

CLUSTER	AUG	SEPT	OCT	NOV	DEC	JAN	FEB	MARCH	APRIL	MAY	JUNE
1. Learning											
2. Time, Weather & Sky											
3. Animals											
4. Plants											
5. Food & Nutrition											
6. Health & Safety											
7. Way-finding											
8. Energy & Communication											
9. Conserv., Recycling & Decomp.											
10. Matter, Space & Construct.											
NOTES and ORGANIZING IDEAS											

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DASH

DASH K–6
SCOPE & SEQUENCE

GRADES K–5 DASH SCOPE AND SEQUENCE OF ACTIVITIES

CLUSTER	GRADE K	GRADE 1	GRADE 2	GRADE 3	GRADE 4	GRADE 5
Learning	Learning Calendar Home Learning Calendar Calendar Review Responsibility Chart Science Record Book Using Our Senses Same and Different Physical Characteristics Functions of Things Working Dictionary Wonder and Discover Book Connections Book Families Families and Helping Making Friends Being Friends School and Home Concept and Skill Inventory	Learning Calendar Responsibility Chart Planning Calendar Last Year Helping Working Together Taking Turns and Sharing Concept and Skill Inventory	Learning Calendar Last Year Aphorisms Helping Others Getting Help Making and Keeping Friends Turns School, Teacher, Friends, and Family Predictions about Tomorrow Planning for Tomorrow Thinking Library Concept and Skill Inventory	Learning Calendar Last Year Responsibility Planning Organizing Our Environment Friends Giving and Receiving Working Together Helping Myself and Others Aphorisms Next Year Science & Technology Concept and Skill Inventory	Learning Calendar Responsibility Last Year Library Working Together Things I Can Do for Myself and Others Aphorisms Planning Survival Game Concept and Skill Inventory	Learning Calendar Responsibility Library Working Together Things I Can Do for Myself and Others Aphorisms Friendship Concept and Skill Inventory
Time, Weather, and Sky	Weather Watch Beginnings Endings Day and Night Days, Weeks, and Months Moon Watch Moon Phases Seasons Clocks and Calendars	Sky and Weather Watch Rain and Streams Snow and Streams Digital Clock Hours and Minutes Time Line Sunrise and Sunset Night and Day The Sun The Seasons Making a Clock	Temperature Wind Sunrise, Sunset, and Seasons Moonrise and Moonset Rain Snow Digital Time Analog Time	Weather Temperature Wind Rain and Snow Humidity Sunrise and Sunset Moon Phases Polar Sky Model Polar Constellations Venus Eclipses	Rainfall and Snowfall Wind Direction & Speed Height of Clouds Clouds and Weather Storm Clouds Humidity and Wind Chill Lightning Weather Maps Weather Fronts Predicting Weather Flat or Round Earth? Length of Day and Night The Sun's Shadow Path The Planetarium Planets When Is It Noon? Making and Using a Sundial Seasons and the Sun Moon Phases and the Sun Eclipses	Weather Station Heat Index Weather Prediction Clouds and Fronts Triangles Gnomon Size of Earth Moon Through a Telescope How Big and Far Away Is the Moon? Paths of Celestial Bodies Models of the Solar System

GRADES K–5 DASH SCOPE AND SEQUENCE OF ACTIVITIES

CLUSTER	GRADE K	GRADE 1	GRADE 2	GRADE 3	GRADE 4	GRADE 5
Animals	Appropriate Pets Classroom Animals Caring for Animals Living, Once-living, and Nonliving Things Animals and Plants Animal Environments Uses for Animals How Bugs Walk Parts of Bugs Parts of Mammals People Animals and Food Animals and Water Animals and Air Animal Wastes How Animals Keep Warm How Animals Keep Cool Real or Imaginary	Classroom Pets Living &and Nonliving Things Defining Living and Nonliving Things Animal Survey Animal Key Animal Needs Planning to Raise a Small Animal Building Cages Metamorphosis	Classroom Pets Classroom Aquarium External Anatomy of Fish Biological Needs of Fish Reproduction and Development of Fish Finding Insect Eggs Hatching Insect Eggs Early Metamorphosis Late Metamorphosis Collecting Spiders Insects and Spiders Spider Food Spider Care Spiders as Predators Spider Webs	Classroom Pets Raising Insects Comparing Insects Importance of Insects Frog and Toad Habitats Raising Frogs and Toads Frog Metamorphosis Importance of Frogs and Toads Toads and Insects Hatching Chicks Chick Growth Importance of Birds	Pet Care Unincubated Egg Chick Embryology Raising Small Mammals Reproduction of Pet Mammals Pet Baby Care Our Early Years The First Grade Child Development of Pets Human Development Changing Dimensions Anatomy of Fish Fish Reproduction Digestive, Circulatory, and Reproductive Systems Migration and Hibernation Fall, Winter, and Spring Birds	Pet Care Birds I Know Cells Male Urogenital System Female Urogenital System Ovulation Cycle Ovulation and Pregnancy Embryology Body Changes Bones Skeletal System Muscles Muscular System Chemistry and Bones The Senses The Eye Sound The Ear
Plants	Plant Parts Plant Environment Plant Uses Growing Bean Sprouts Plants and Water Gardening	Plant Identification Plant Survey Plant Pressing Plant Key Plant Needs Plant Life Cycle Edible Plant Parts Plant Parts Animals Eat	Soil Making Soil Soil and Plants Soil Uses Finding Soil Pipes and Water Moving Water: Gravity Moving Water: Pumps Vegetable and Flower Gardens in a Bucket Rooting Stems Rooting Bulbs and Tubers Roots and Water Growing Root Vegetables Tree Planting	Garden Planning Garden Preparation Watching Garden Soil Making Artificial Soil Testing Soil Soil and Water Garden Planting Garden Care Watering Systems Garden Invaders Controlling Insects Garden Harvesting Flowers Seeds Pollination	Annual, Biennial, and Perennial Plants Fungi	Annual, Biennial, and Perennial Plant Project Tree Harvesting Tree Planting Tree Observation Measuring Trees Age of Trees Trees, Shrubs, and Grasses Grasses: Why Do They Grow There? Roots Soil Conservation
Food and Nutrition	Bean Sprout Salad Drinks Flour and Bread Familiar Foods Favorite Foods New Foods	Food Groups Cooking Measuring Volume	Supermarket Survey Food Preference Food Groups New Foods Properties of Foods Changing Flavor Milk, Butter, and Cheese Energy from Food	Nutritious Food Selection Plants for the Garden Class Feast Drying and Pickling Foods Preserving and Rotting Supermarket Game Pricing Foods Food Ads	Nutrients Mechanical Digestion Chemical Digestion Food Groups Preserving Foods	Nutrients Nutrients and Cells Food Labeling

GRADES K–5 DASH SCOPE AND SEQUENCE OF ACTIVITIES

CLUSTER	GRADE K	GRADE 1	GRADE 2	GRADE 3	GRADE 4	GRADE 5
Health and Safety	Growth Chart Tooth Chart Tooth Care Exercise Germs Washing Hands Bathrooms and Basins Aprons Fountains and Faucets Getting Sick Feeling Sick Going to the Doctor What Doctors Do Going to the Hospital Raincoats Testing Raincoats Wet and Cold Keeping Warm Indoors Hand and Foot Protection Getting Lost	Growth Chart Tooth Chart Brushing Teeth Chewing Air and Breathing Getting Hurt Staying Healthy Safety Rules	Growth Chart Tooth Chart Tooth Care Getting Hurt Getting Sick Staying Well Classroom and Playground Safety Fire Safety Using 911	Growth Chart Tooth Chart Breathing Air Anatomy of Breathing Lung Model Lungs and Smoking Breathing and Pulse Heart, Veins, and Arteries Heart, Lungs, and Exercise Disease Transmission Trash and Sanitation Helpful Drugs Proper Drug Use	Growth Chart and Area Measurement Tooth Chart Safety Gear Safety and Putting Out Fires Making a Fire Things That Burn Smoking and the Lungs Alcohol, Tobacco, and Drugs	Growth Chart and Area Measurement Tooth Chart Alcohol, Tobacco, and Drugs Sexually Transmitted Diseases Safety Devices Smokers' Surveys Smoking Laws Alcohol Laws Chris's Story The Parents' Story Intoxication Drug Laws
Wayfinding and Transportation	Right and Left Sunrise Sunset North and South Rising Moon Setting Moon Home Location Sidewalks & Walkways Roads Traffic Simulation Traffic Rules Mapping	Pacing North, South, East, and West Home Map Distance Making a Boat Making a Lake The Great Regatta Floating and Sinking Draining a Lake	Transportation Systems Making Race Cars Racing Cars Roads Building a Village Pedestrians in the Village Bikes in the Village Cars in the Village Bikes and Trikes Belts and Pulleys Fast and Slow Pulleys Gears and Wheels	Garden Mover Propeller-Driven Message Center Propeller-driven Boat Delivery Systems	Boat Design Wind and Sails	Where in the World Are We? Planetarium Mapping the Sky The North Pole, Equator, and Ecliptic Where Is Earth?

GRADES K–5 DASH SCOPE AND SEQUENCE OF ACTIVITIES

CLUSTER	GRADE K	GRADE 1	GRADE 2	GRADE 3	GRADE 4	GRADE 5
Energy and Communication	Energy Making Things Move Making Things Stop Turning Things Off Turning Things On Repairing Things	Temperature of Things Master Thermometer Hot and Cold Sources of Energy	Sun and Direction Mirrors and Sunlight Clouds and Sunlight Comparing Temperatures Eclipses	Shadow, Light, and Bubbles Wind and Heat Wind Pulls and Pushes Propellers Driving Propellers Waterwheels Propellers in Water Heliograph Speaking Tube String Telephone Energy Definitions	Push-Pull Measuring Tool Friction Streamlining Pressure, Sharp Edges, and Points Energy of Falling Objects Circles and Speed	Pushes, Pulls, & Forces Teeter-Totters The Balance Wheels and Axles Levers Arms and Jaws Inclined Planes and Screws Block and Tackle Magnetic Pushes and Pulls Magnets and Compasses Magnetic Fields Forces Projects
Conservation, Recycling, and Decomposition	Decomposition Waste Disposal Recycling Project Making Paper	Classroom Resources Conserving Energy Conserving Water Decomposition and Unearthing Decomposition and Reburial Recycling	Fall Unearthing Fall Burying Spring Unearthing Spring Burying Pollution Survey Aluminum Recycling Connections	Making Compost Watching Compost Animals in Compost Using Compost Fall Unearthing and Burial Spring Unearthing and Burial	Unearthing and Burial Recycling Project	Class Recycling Project Class Conservation Project Decomposition and Archeology Pollution Project
Matter, Space, and Construction	Cubby Organization Patterns in Puzzles Making Puzzles Making Envelopes Making Boxes and Bags Volume of Boxes and Bags Packing and Storing Linear Measurement	Meter-string Can Outdoor Study Area Mapping Testing for Water Measuring Volume Plumbing Water Systems Air Bubbles in Water and Air Building with Air Floor Plan Cardboard House Plan Making a Cardboard House Painting the House Furnishing the House Sewing and Weaving Warming andCooling Lighting the House	Desk Organization Notebook Organization The Balance Meter-string Can Measuring Volume	Acidic and Basic Soil Acids and Bases Acid and Base Reactions Diluting Acids and Bases Acid and Base Interactions Dissolving Things Things in Liquids Crystals Rain in a Jar Supermarket Planning Supermarket Construction Measuring Devices Safety Equipment	Linear Measurement Volume Measurement Mass Measurement Collecting Rocks Hardness of Rocks Specific Gravity Rocks and Sharp Edges Making Tools from Rock Clowns: Things That Float Clay Fire and Pottery Air and Fire Fire and Oxygen Properties of Gas	Linear Measurement Volume Measurement Mass Measurement Camera Obscura Controlling Light with Lenses Making a Telescope Stabilizing the Telescope Making a Microscope Making a Hygrometer Making a Barometer

GRADE 6 SCOPE AND SEQUENCE OF ACTIVITIES

Learning	Time, Weather, and Sky	Animals	Plants	Food and Nutrition
Learning Calendar Last Year Mars Mission Tomorrow The Work World Goals Crash Simulation Mars Compact Martian Simulation The Mission Conference Concept and Skill Inventory	Weather Station Weather Around the United States Weather and Local Climate Wind Hypotheses Producing Winds Air Pressure and Altitude Wind and Water Altitude and Temperature Models of Air Climatic Regions Climate of Mars	Animal Care Raising Fish Raising Worms Food Chains	Hydroponics Algae Nutrients and Biological Waste Water Pollutants	Nutrient Tables The Kilocalorie Weight Watching Meal Planning Food for Space Fish and Algae for Dinner
Health and Safety	**Wayfinding and Transportation**	**Energy and Communication**	**Conservation, Recycling, and Decomposition**	**Matter, Space, and Construction**
Growth Chart Tooth Chart Safety Disease Literature Sanitation Disease Prevention and Treatment Sexually Transmitted Diseases Drug Abuse Prevention and Treatment Alcohol and Tobacco Addiction, Prevention, and Treatment Environmental Disease Transmission, Prevention, and Treatment Exercise and Health and the Mars Mission	Flying Airplanes Flying Rockets Spacecraft The Orbit of Mars What Path to Mars?	Rocket Propulsion Magnetism Electrostatics Electrical Circuits Rock Formation Metals from Ores Asymmetrical Levers	Recycling Project Conservation Decomposition: A Summary Pollution	Making Measuring Equipment Making a Balance Making an Electroscope Making Electromagnets and Current Indicators Electric Cells Making an Electric Motor Making an Electric Signaler Making a Martian Survival Habitat

GRADE 6 SCOPE AND SEQUENCE OF ACTIVITIES

Learning	Time, Weather, and Sky	Animals	Plants	Food and Nutrition
Learning Calendar Last Year Mars Mission Tomorrow The Work World Goals Crash Simulation Mars Compact Martian Simulation The Mission Conference Concept and Skill Inventory	Weather Station Weather Around the United States Weather and Local Climate Wind Hypotheses Producing Winds Air Pressure and Altitude Wind and Water Altitude and Temperature Models of Air Climatic Regions Climate of Mars	Animal Care Raising Fish Raising Worms Food Chains	Hydroponics Algae Nutrients and Biological Waste Water Pollutants	Nutrient Tables The Kilocalorie Weight Watching Meal Planning Food for Space Fish and Algae for Dinner
Health and Safety	**Wayfinding and Transportation**	**Energy and Communication**	**Conservation, Recycling, and Decomposition**	**Matter, Space, and Construction**
Growth Chart Tooth Chart Safety Disease Literature Sanitation Disease Prevention and Treatment Sexually Transmitted Diseases Drug Abuse Prevention and Treatment Alcohol and Tobacco Addiction, Prevention, and Treatment Environmental Disease Transmission, Prevention, and Treatment Exercise and Health and the Mars Mission	Flying Airplanes Flying Rockets Spacecraft The Orbit of Mars What Path to Mars?	Rocket Propulsion Magnetism Electrostatics Electrical Circuits Rock Formation Metals from Ores Asymmetrical Levers	Recycling Project Conservation Decomposition: A Summary Pollution	Making Measuring Equipment Making a Balance Making an Electroscope Making Electromagnets and Current Indicators Electric Cells Making an Electric Motor Making an Electric Signaler Making a Martian Survival Habitat

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DASH K
ACTIVITY LIST

CLUSTER 1 LEARNING

K.1.1 THE LEARNING CALENDAR
K.1.2 THE CLASS RESPONSIBILITY CHART
K.1.3 CALENDAR REVIEW
K.1.4 THE HOME LEARNING CALENDAR
K.1.5 THE SCIENCE RECORD BOOK
K.1.6 USING OUR SENSES
K.1.7 SAME AND DIFFERENT
K.1.8 PHYSICAL CHARACTERISTICS OF THINGS
K.1.9 FUNCTIONS OF THINGS
K.1.10 THE WORKING DICTIONARY AND WORKING DEFINITIONS
K.1.11 THE WONDER AND DISCOVER BOOK
K.1.12 THE CONNECTIONS BOOK
K.1.13 FAMILIES
K.1.14 FAMILIES AND HELPING
K.1.15 MAKING FRIENDS
K.1.16 BEING FRIENDS
K.1.17 SCHOOL AND HOME
K.1.18 CONCEPT AND SKILL INVENTORY

CLUSTER 2 TIME, WEATHER, AND SKY

K.2.1 WEATHER WATCH
K.2.2 BEGINNINGS
K.2.3 ENDINGS
K.2.4 DAY AND NIGHT
K.2.5 DAYS, WEEKS, AND MONTHS
K.2.6 MOON WATCH
K.2.7 MOON PHASES
K.2.8 SEASONS
K.2.9 CLOCKS AND CALENDARS

CLUSTER 3 ANIMALS

K.3.1 APPROPRIATE PETS
K.3.2 CLASSROOM ANIMALS
K.3.3 CARING FOR CLASSROOM ANIMALS
K.3.4 LIVING, ONCE-LIVING, AND NOT-LIVING
K.3.5 ANIMALS AND PLANTS
K.3.6 ANIMAL ENVIRONMENTS
K.3.7 USES FOR ANIMALS
K.3.8 HOW BUGS WALK
K.3.9 PARTS OF BUGS
K.3.10 PARTS OF MAMMALS
K.3.11 PEOPLE
K.3.12 ANIMALS AND FOOD
K.3.13 ANIMALS AND WATER
K.3.14 ANIMALS AND AIR
K.3.15 ANIMAL WASTES
K.3.16 HOW ANIMALS KEEP WARM
K.3.17 HOW ANIMALS KEEP COOL
K.3.18 REAL OR IMAGINARY

CLUSTER 4 PLANTS

K.4.1 PLANT PARTS
K.4.2 PLANT ENVIRONMENTS
K.4.3 PLANT USES
K.4.4 GROWING BEAN SPROUTS
K.4.5 PLANTS AND WATER
K.4.6 GARDENING

CLUSTER 5 FOOD AND NUTRITION

K.5.1 BEAN SPROUT SALAD
K.5.2 DRINKS
K.5.3 FLOUR AND BREAD
K.5.4 FAMILIAR FOODS
K.5.5 FAVORITE FOODS
K.5.6 NEW FOODS
K.5.7 SNACKS FROM THE GARDEN

CLUSTER 6 HEALTH AND SAFETY

K.6.1 GROWTH CHART
K.6.2 TOOTH CHART
K.6.3 TOOTH CARE
K.6.4 EXERCISE
K.6.5 GERMS
K.6.6 WASHING HANDS
K.6.7 BATHROOMS AND BASINS
K.6.8 APRONS
K.6.9 FOUNTAINS AND FAUCETS
K.6.10 GETTING SICK
K.6.11 FEELING SICK
K.6.12 GOING TO THE DOCTOR
K.6.13 WHAT DOCTORS DO
K.6.14 GOING TO THE HOSPITAL
K.6.15 RAINCOATS
K.6.16 TESTING RAINCOATS
K.6.17 WET AND COLD
K.6.18 KEEPING WARM INDOORS
K.6.19 KEEPING COOL INDOORS
K.6.20 HAND AND FOOT PROTECTION
K.6.21 GETTING LOST

CLUSTER 7 WAYFINDING AND TRANSPORTATION

K.7.1 RIGHT AND LEFT
K.7.2 SUNRISE
K.7.3 SUNSET
K.7.4 NORTH AND SOUTH
K.7.5 HOME LOCATION
K.7.6 SIDEWALKS AND WALKWAYS
K.7.7 ROADS
K.7.8 TRAFFIC SIMULATION EQUIPMENT
K.7.9 TRAFFIC SIMULATION MAPPING
K.7.10 TRAFFIC SIMULATION RULES
K.7.11 CLASSROOM MAPPING

CLUSTER 8 ENERGY AND COMMUNICATION

K.8.1 ENERGY
K.8.2 MAKING THINGS MOVE
K.8.3 MAKING THINGS STOP
K.8.4 TURNING THINGS OFF
K.8.5 TURNING THINGS ON
K.8.6 REPAIRING THINGS

CLUSTER 9 CONSERVATION, RECYCLING, AND DECOMPOSITION

K.9.1 DECOMPOSTITION
K.9.2 WASTE DISPOSAL
K.9.3 RECYCLING PROJECT
K.9.4 MAKING PAPER

CLUSTER 10 MATTER, SPACE, AND CONSTRUCTION

K.10.1 CUBBY ORGANIZATION
K.10.2 PATTERNS IN PUZZLES
K.10.3 MAKING ENVELOPES
K.10.4 MAKING PUZZLES
K.10.5 MAKING BOXES AND BAGS
K.10.6 VOLUME OF BOXES AND BAGS
K.10.7 PACKING AND STORING
K.10.8 LINEAR MEASUREMENT

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DASH 1
ACTIVITY LIST

CLUSTER 1 LEARNING

1.1.1 THE LEARNING CALENDAR
1.1.2 THE RESPONSIBILITY CHART
1.1.3 THE PLANNING CALENDAR
1.1.4 THING LEARNED LAST YEAR
1.1.5 HELPING
1.1.6 WORKING TOGETHER
1.1.7 TAKING TURNS AND SHARING
1.1.8 CONCEPT AND SKILL INVENTORY

CLUSTER 2 TIME, WEATHER, AND SKY

1.2.1 SKY AND WEATHER WATCH
1.2.2 RAIN AND STREAMS
1.2.3 SNOW AND STREAMS
1.2.4 THE DIGITAL CLOCK
1.2.5 HOURS AND MINUTES
1.2.6 TIME LINE
1.2.7 SUNRISE AND SUNSET
1.2.8 NIGHT AND DAY
1.2.9 THE SUN
1.2.10 THE SEASONS
1.2.11 MAKING A CLOCK
1.2.12 MOONRISE AND MOON SET

CLUSTER 3 ANIMALS

1.3.1 LIVING AND NON-LIVING THINGS
1.3.2 DEFINING LIVING AND NON-LIVING THINGS
1.3.3 ANIMAL SURVEY
1.3.4 ANIMAL KEY
1.3.5 ANIMAL NEEDS
1.3.6 PLANNING TO RAISE A SMALL ANIMAL
1.3.7 BUILDING CAGES
1.3.8 METAMORPHOSIS
1.3.9 CLASSROOM PETS

CLUSTER 4 PLANTS

1.4.1 PLANT IDENTIFICATION
1.4.2 PLANT SURVEY
1.4.3 PLANT PRESSING
1.4.4 PLANT KEY
1.4.5 PLANT NEEDS
1.4.6 PLANT LIFE CYCLE
1.4.7 EDIBLE PLANT PARTS
1.4.8 PLANT PARTS ANIMALS EAT

CLUSTER 5 FOOD AND NUTRITION

1.5.1 BASIC THREE FOOD GROUPS
1.5.2 COOKING
1.5.3 MEASURING VOLUME

CLUSTER 6 HEALTH AND SAFETY

1.6.1 GROWTH CHART
1.6.2 TOOTH CHART
1.6.3 BRUSHING TEETH
1.6.4 CHEWING
1.6.5 AIR AND BREATHING
1.6.6 GETTING HURT
1.6.7 STAYING HEALTHY
1.6.8 SAFETY RULES

CLUSTER 7 WAYFINDING AND TRANSPORTATION

1.7.1 PACING
1.7.2 NORTH, SOUTH, EAST, AND WEST
1.7.3 HOME
1.7.4 MAP DISTANCE
1.7.5 MAKING A BOAT
1.7.6 MAKING A LAKE
1.7.7 THE GREAT REGATTA
1.7.8 FLOATING AND SINKING
1.7.9 DRAINING A LAKE

CLUSTER 8 ENERGY AND COMMUNICATION

1.8.1 TEMPERATURE OF THINGS
1.8.2 THE MASTER THERMOMETER
1.8.3 HOT AND COLD
1.8.4 SOURCES OF ENERGY

CLUSTER 9 CONSERVATION, RECYCLING, AND DECOMPOSTITION

1.9.1 CONSERVING CLASSROOM RESOURCES
1.9.2 CONSERVING ENERGY
1.9.3 CONSERVING WATER
1.9.4 DECOMPOSITION AND UNEARTHING
1.9.5 DECOMPOSITION AND REBURIAL
1.9.6 RECYCLING

CLUSTER 10 MATTER, SPACE, AND CONSTRUCTION

1.10.1 METER–STRING CAN
1.10.2 OUTDOOR STUDY AREA MAPPING
1.10.3 TESTING FOR WATER
1.10.4 PLUMBING
1.10.5 WATER SYSTEMS
1.10.6 AIR
1.10.7 BUBBLES IN WATER
1.10.8 BUBBLES IN AIR
1.10.9 BUILDING WITH AIR
1.10.10 FLOOR PLAN
1.10.11 FLOOR PLAN MODEL
1.10.12 CARDBOARD HOUSE PLAN
1.10.13 MAKING A CARDBOARD HOUSE
1.10.14 PAINTING THE HOUSE
1.10.15 FURNISHING THE HOUSE
1.10.16 SEWING
1.10.17 WEAVING
1.10.18 WARMING AND COOLING THE HOUSE
1.10.19 LIGHTING THE HOUSE
1.10.20 SAFETY EQUIPMENT

DASH 2
ACTIVITY LIST

CLUSTER 1 LEARNING

2.1.1 THE LEARNING CALENDAR
2.1.2 LAST YEAR
2.1.3 APHORISMS
2.1.4 HELPING MYSELF AND OTHERS
2.1.5 GETTING HELP
2.1.6 MAKING AND KEEPING FRIENDS
2.1.7 TURNS
2.1.8 SCHOOL, TEACHER, FRIENDS, AND FAMILY
2.1.9 PREDICTIONS ABOUT TOMORROW
2.1.10 PLANNING FOR TOMORROW
2.1.11 THINKING
2.1.12 LIBRARY
2.1.13 CONCEPT AND SKILL INVENTORY

CLUSTER 2 TIME, WEATHER, AND SKY

2.2.1 TEMPERATURE
2.2.2 WIND
2.2.3 SUNRISE, SUNSET, AND SEASONS
2.2.4 MOONRISE AND MOONSET
2.2.5 RAIN
2.2.6 SNOW
2.2.7 DIGITAL TIME
2.2.8 ANALOG TIME

CLUSTER 3 ANIMALS

2.3.1 THE CLASSROOM AQUARIUM
2.3.2 EXTERNAL ANATOMY OF FISH
2.3.3 BIOLOGICAL NEEDS OF FISH
2.3.4 REPRODUCTION AND DEVELOPMENT OF FISH
2.3.5 FINDING INSECT EGGS
2.3.6 HATCHING INSECT EGGS
2.3.7 EARLY METAMORPHOSIS
2.3.8 LATE METAMORPHOSIS
2.3.9 COLLECTING SPIDERS
2.3.10 SPIDER FOOD
2.3.11 SPIDER CARE
2.3.12 SPIDERS AS PREDATORS
2.3.13 SPIDER WEBS
2.3.14 CLASSROOM PETS

CLUSTER 4 PLANTS

2.4.1 SOIL
2.4.2 MAKING SOIL
2.4.3 SOIL AND PLANTS
2.4.4 SOIL USES
2.4.5 FINDING SOIL
2.4.6 PIPES AND WATER
2.4.7 MOVING WATER
2.4.8 MOVING WATER WITH PUMPS
2.4.9 VEGETABLE GARDEN IN A BUCKET
2.4.10 FLOWER GARDEN IN A BUCKET
2.4.11 PLANTS AND SUNLIGHT
2.4.12 ROOTING STEMS
2.4.13 ROOTING BULBS AND TUBERS
2.4.14 ROOTS AND WATER
2.4.15 GROWING ROOT VEGETABLES
2.4.16 TREE PLANTING

CLUSTER 5 FOOD AND NUTRITION

2.5.1 SUPERMARKET SURVEY
2.5.2 FOOD PREFERENCES
2.5.3 BASIC THREE FOOD GROUPS
2.5.4 NEW FOODS
2.5.5 IDENTIFYING PROPERTIES OF VEGETABLES
2.5.6 CHANGING FLAVOR
2.5.7 MILK
2.5.8 BUTTER
2.5.9 CHEESE
2.5.10 ENERGY FROM FOOD

CLUSTER 6 HEALTH AND SAFETY

2.6.1 GROWTH CHART
2.6.2 TOOTH CHART
2.6.3 TOOTH CARE
2.6.4 GETTING HURT
2.6.5 GETTING SICK
2.6.6 STAYING WELL
2.6.7 CLASSROOM AND PLAYGROUND SAFETY
2.6.8 FIRE SAFETY
2.6.9 USING 911

CLUSTER 7 WAYFINDING AND TRANSPORTATION

2.7.1 TRANSPORTATION SYSTEMS
2.7.2 MAKING RACE CARS
2.7.3 RACING AND MODIFYING CARS
2.7.4 ROADS
2.7.5 BUILDING A VILLAGE
2.7.6 PEDESTRIANS IN THE VILLAGE
2.7.7 BIKES IN THE VILLAGE
2.7.8 CARS IN THE VILLAGE
2.7.9 BIKES AND TRIKES
2.7.10 BELTS AND PULLEYS
2.7.11 FAST AND SLOW PULLEYS
2.7.12 GEARS AND WHEELS

CLUSTER 8 ENERGY AND COMMUNICATION

2.8.1 CAMERA OBSCURA
2.8.2 MIRRORS AND SUNLIGHT
2.8.3 CLOUDS AND SUNLIGHT
2.8.4 COMPARING TEMPERATURES
2.8.5 ECLIPSES

CLUSTER 9 CONSERVATION, RECYCLING, AND DECOMPOSITION

2.9.1 FALL UNEARTHING
2.9.2 FALL BURYING
2.9.3 SPRING UNEARTHING
2.9.4 SPRING BURYING
2.9.5 POLLUTION SURVEY AND CLEANUP
2.9.6 ALUMINUM RECYCLING
2.9.7 CONNECTIONS

CLUSTER 10 MATTER, SPACE, AND CONSTRUCTION

2.10.1 DESK ORGANIZATION
2.10.2 NOTEBOOK ORGANIZATION
2.10.3 THE BALANCE
2.10.4 METER-STRING CAN
2.10.5 MEASURING VOLUME
2.10.6 SAFETY EQUIPMENT

DASH 3
ACTIVITY LIST

CLUSTER 1 LEARNING

3.1.1 THE LEARNING CALENDAR
3.1.2 LAST YEAR
3.1.3 RESPONSIBILITY
3.1.4 PLANNING
3.1.5 ORGANIZING OUR ENVIRONMENT
3.1.6 FRIENDS
3.1.7 GIVING AND RECEIVING
3.1.8 WORKING TOGETHER
3.1.9 HELPING MYSELF AND OTHERS
3.1.10 APHORISMS
3.1.11 NEXT YEAR
3.1.12 CAREY'S GARDEN
3.1.13 CONCEPT AND SKILL INVENTORY

CLUSTER 2 TIME, WEATHER, AND SKY

3.2.1 WEATHER
3.2.2 TEMPERATURE
3.2.4 WIND
3.2.5 RAIN AND SNOW
3.2.6 HUMIDITY
3.2.7 MOON PHASES
3.2.8 POLAR SKY MODEL
3.2.9 POLAR CONSTELLATIONS
3.2.10 VENUS
3.2.11 ECLIPSES

CLUSTER 3 ANIMALS

3.3.1 CLASSROOM PETS
3.3.2 PREPARING TO RAISE INSECTS
3.3.3 RAISING INSECTS
3.3.4 IMPORTANCE OF INSECTS
3.3.5 NATURAL HABITATS OF FROGS AND TOADS
3.3.6 MAKING HABITATS FOR FROGS AND TOADS
3.3.7 FROG METAMORPHOSIS
3.3.8 IMPORTANCE OF FROGS AND TOADS
3.3.9 TOADS AND INSECTS
3.3.10 HATCHING CHICKS
3.3.11 CHICK GROWTH
3.3.12 IMPORTANCE OF BIRDS

CLUSTER 4 PLANTS

3.4.1 GARDEN PLANNING
3.4.2 GARDEN PREPARATION
3.4.3 WATCHING GARDEN SOIL
3.4.4 MAKING ARTIFICIAL SOIL
3.4.5 TESTING ARTIFICIAL SOIL
3.4.6 SOIL AND WATER
3.4.7 GARDEN PLANTING
3.4.8 GARDEN CARE
3.4.9 GARDEN WATERING SYSTEMS
3.4.10 GARDEN INVADERS
3.4.11 CONTROLLING INSECTS
3.4.12 GARDEN HARVESTING
3.4.13 FLOWERS
3.4.14 SEEDS
3.4.15 POLLINATION

CLUSTER 5 FOOD AND NUTRITION

3.5.1 FOOD SELECTION
3.5.2 SELECTING PLANTS FOR THE GARDEN
3.5.3 PLANNING THE CLASS FEAST
3.5.4 PREPARING THE CLASS FEAST
3.5.5 THE CLASS FEAST
3.5.6 DRYING FOODS
3.5.7 PICKLING FOODS
3.5.8 PRESERVING AND ROTTING
3.5.9 SUPERMARKET GAME PREPARATION
3.5.10 PRICING FOODS
3.5.11 NEWSPAPER ADS AND BANKING
3.5.12 FARMERS AND PROCESSORS
3.5.13 SUPERMARKET GAME

CLUSTER 6 HEALTH AND SAFETY

3.6.1 GROWTH CHART
3.6.2 TOOTH CHART
3.6.3 BREATHING AIR
3.6.4 ANATOMY OF BREATHING
3.6.5 LUNG MODEL
3.6.6 LUNGS AND SMOKING
3.6.7 BREATHING AND PULSE RATES
3.6.8 HEART, VEINS, AND ARTERIES
3.6.9 HEART, LUNGS, AND EXERCISE
3.6.10 DISEASE TRANSMISSION
3.6.11 TRASH AND SANITATION
3.6.12 HELPFUL DRUGS
3.6.13 PROPER DRUG USE

CLUSTER 7 WAYFINDING AND TRANSPORTATION

3.7.1 GARDEN MOVER
3.7.2 PROPELLER-DRIVEN MESSAGE CENTER
3.7.3 PROPELLER-DRIVEN BOAT
3.7.4 DELIVERY SYSTEMS

CLUSTER 8 ENERGY AND COMMUNICATION

3.8.1 SHADOW, LIGHT, AND BUBBLES
3.8.2 WIND AND HEAT
3.8.3 WIND PULLS AND PUSHES
3.8.4 PROPELLERS DRIVING PROPELLERS
3.8.5 WATERWHEELS
3.8.6 PROPELLERS IN WATER
3.8.7 HELIOGRAPH
3.8.8 SPEAKING TUBE
3.8.9 STRING TELEPHONE
3.8.10 ENERGY DEFINITIONS

CLUSTER 9 CONSERVATION, RECYCLING, AND DECOMPOSITION

3.9.1 MAKING COMPOST
3.9.2 WATCHING COMPOST
3.9.3 ANIMALS IN COMPOST
3.9.4 USING COMPOST
3.9.5 FALL UNEARTHING AND BURIAL
3.9.6 SPRING UNEARTHING AND BURIAL

CLUSTER 10 MATTER, SPACE, AND CONSTRUCTION

3.10.1 ACIDIC AND BASIC SOIL
3.10.2 ACIDS AND BASES
3.10.3 ACID AND BASE REACTIONS
3.10.4 DILUTING ACIDS AND BASES
3.10.5 ACID AND BASE INTERACTION
3.10.6 DISSOLVING THINGS
3.10.7 THINGS IN LIQUIDS
3.10.8 CRYSTALS
3.10.9 RAIN IN A JAR
3.10.10 SUPERMARKET PLANNING
3.10.11 SUPERMARKET CONSTRUCTION
3.10.12 MEASURING DEVICES
3.10.13 SAFETY EQUIPMENT

DASH 4
ACTIVITY LIST

CLUSTER 1 LEARNING

4.1.1 THE LEARNING CALENDAR
4.1.2 RESPONSIBILITY
4.1.3 LAST YEAR
4.1.4 THE LIBRARY
4.1.5 WORKING TOGETHER
4.1.6 THINGS I CAN DO FOR MYSELF AND FOR OTHERS
4.1.7 APHORISMS
4.1.8 PLANNING
4.1.9 SURVIVAL GAME
4.1.10 CONCEPT AND SKILL INVENTORY

CLUSTER 2 TIME, WEATHER, AND SKY

4.2.1 RAINFALL
4.2.2 SNOWFALL
4.2.3 WIND DIRECTION
4.2.4 WIND SPEED
4.2.5 HEIGHT OF CLOUDS
4.2.6 HUMIDITY
4.2.7 CLOUDS AND WEATHER
4.2.8 STORM CLOUDS
4.2.9 LIGHTNING
4.2.10 WEATHER MAPS
4.2.11 WEATHER FRONTS
4.2.12 PREDICTING WEATHER
4.2.13 WIND CHILL
4.2.14 FLAT OR ROUND EARTH
4.2.15 LENGTH OF DAY AND NIGHT
4.2.16 THE SUN'S SHADOW PATH
4.2.17 PLANETARIUM
4.2.18 USING THE PLANETARIUM
4.2.19 PLANETS
4.2.20 WHEN IS IT NOON?
4.2.21 MAKING A SUNDIAL
4.2.22 USING A SUNDIAL
4.2.23 SEASONS AND THE SUN
4.2.24 MOON PHASES AND THE SUN
4.2.25 ECLIPSES

CLUSTER 3 ANIMALS

4.3.1 PET CARE
4.3.2 THE UNINCUBATED EGG
4.3.3 CHICK EMBRYOLOGY
4.3.4 RAISING SMALL MAMMALS
4.3.5 HOUSING PET MAMMALS
4.3.6 WEEKEND CARE OF PET MAMMALS
4.3.7 PAIRING PET MAMMALS
4.3.8 REPRODUCTION OF PET MAMMALS
4.3.9 PET BABY CARE
4.3.10 OUR EARLY YEARS
4.3.11 THE FIRST GRADE CHILD
4.3.12 GROWTH, DEVELOPMENT, AND BEHAVIOR OF YOUNG PETS
4.3.13 HUMAN GROWTH AND DEVELOPMENT
4.3.14 CHANGING DIMENSIONS
4.3.15 EXTERNAL ANATOMY OF FISH
4.3.16 CLEANING FISH: INTERNAL ANATOMY
4.3.17 FISH REPRODUCTION
4.3.18 MODELING OUR DIGESTIVE SYSTEM
4.3.19 OUR DIGESTIVE SYSTEM IN TWO DIMENSIONS
4.3.20 DIGESTIVE, CIRCULATORY, AND RESPIRATORY SYSTEMS
4.3.21 LENGTH OF THE DIGESTIVE TRACT
4.3.22 MIGRATION AND HIBERNATION
4.3.23 FALL BIRDS
4.3.24 WINTER BIRDS
4.3.25 SPRING BIRDS

CLUSTER 4 PLANTS

4.4.1 ANNUAL, BIENNIAL, AND PERENNIAL GARDEN PLANTS
4.4.2 THE FUNGUS AMONG US
4.4.3 FUNGUS COLLECTION

CLUSTER 5 FOOD AND NUTRITION

4.5.1 NUTRITION MESSAGES
4.5.2 MECHANICAL DIGESTION
4.5.3 CHEMICAL DIGESTION
4.5.4 FOOD GROUPS
4.5.5 DIGESTION GAME
4.5.6 PRESERVING FOODS

CLUSTER 6 HEALTH AND SAFETY

4.6.1 GROWTH CHART AND AREA MEASUREMENT
4.6.2 TOOTH CHART
4.6.3 SAFETY GEAR
4.6.4 SAFETY AND PUTTING OUT FIRES
4.6.5 MAKING A FIRE
4.6.6 THINGS THAT BURN
4.6.7 SMOKING AND THE LUNGS
4.6.8 ALCOHOL, TOBACCO, AND DRUGS

CLUSTER 7 WAYFINDING AND TRANSPORTATION

4.7.1 BOAT DESIGN
4.7.2 WIND AND SAILS

CLUSTER 8 ENERGY AND COMMUNICATION

4.8.1 PUSH-PULL MEASURING TOOL
4.8.2 FRICTION
4.8.3 STREAMLINING
4.8.4 PRESSURE, SHARP EDGES, AND POINTS
4.8.5 ENERGY OF FALLING OBJECTS
4.8.6 CIRCLES AND SPEED

CLUSTER 9 CONSERVATION, RECYCLING, AND DECOMPOSTION

4.9.1 UNEARTHING
4.9.2 RECYCLING PROJECT

CLUSTER 10 MATTER, SPACE, AND CONSTRUCTION

4.10.1 LINEAR MEASUREMENT
4.10.2 VOLUME MEASUREMENT
4.10.3 MASS MEASUREMENT
4.10.4 COLLECTING ROCKS
4.10.5 HARDNESS OF ROCKS
4.10.6 SPECIFIC GRAVITY
4.10.7 ROCKS AND SHARP EDGES
4.10.8 MAKING TOOLS FROM ROCK
4.10.9 MAKING FISHING TOOLS
4.10.10 CLOWNS: THINGS THAT FLOAT
4.10.11 CLAY
4.10.12 FIRE AND POTTERY
4.10.13 AIR AND FIRE
4.10.14 FIRE AND OXYGEN
4.10.15 PROPERTIES OF GASES

BEST COPY AVAILABLE

DASH 5
ACTIVITY LIST

CLUSTER 1 LEARNING

5.1.1	THE LEARNING CALENDAR
5.1.2	RESPONSIBILITY
5.1.3	LIBRARY CHECK-OUT
5.1.4	LIBRARY CHECK-IN
5.1.5	WORKING TOGETHER
5.1.6	THINGS I CAN DO FOR MYSELF AND OTHERS
5.1.7	APHORISMS
5.1.8	FRIENDSHIP
5.1.9	CONCEPT AND SKILL INVENTORY

CLUSTER 2 TIME, WEATHER, AND SKY

5.2.1	WEATHER STATION
5.2.2	HEAT INDEX
5.2.3	WEATHER AND ITS PREDICTION
5.2.4	CLOUDS AND FRONTS
5.2.5	TRIANGLES
5.2.6	GNOMON
5.2.7	SIZE OF THE EARTH
5.2.8	MOON THROUGH A TELESCOPE
5.2.9	HOW BIG AND FAR AWAY IS THE MOON?
5.2.10	PATHS OF CELESTIAL BODIES
5.2.11	MODELS OF THE SOLAR SYSTEM

CLUSTER 3 ANIMALS

5.3.1	PET CARE
5.3.2	BIRD FEEDER
5.3.3	BIRDS I KNOW
5.3.4	CELLS
5.3.5	CELL QUIZ
5.3.6	MALE UROGENITAL SYSTEM
5.3.7	FEMALE UROGENITAL SYSTEM
5.3.8	OVULATION CYCLE
5.3.9	OVULATION AND PREGNANCY
5.3.10	EMBRYOLOGY
5.3.11	BODY CHANGES
5.3.12	BONES
5.3.13	SKELETAL SYSTEM
5.3.14	MUSCLES
5.3.15	MUSCULAR SYSTEM
5.3.16	CHEMISTRY AND BONES
5.3.17	THE SENSES
5.3.18	THE EYE
5.3.19	SOUND
5.3.20	THE EAR

CLUSTER 4 PLANTS

5.4.1	ANNUAL, BIENNIAL, AND PERENNIAL PLANT PROJECT
5.4.2	TREE HARVESTING
5.4.3	TREE PLANTING
5.4.4	TREE OBSERVATION
5.4.5	MEASURING TREES
5.4.6	AGE OF TREES
5.4.7	TREES, SHRUBS, AND GRASSES
5.4.8	GRASSES: WHY DO THEY GROW THERE?
5.4.9	ROOTS
5.4.10	SOIL CONSERVATION

CLUSTER 5 FOOD AND NUTRITION

5.5.1	NUTRIENTS
5.5.2	NUTRIENTS AND CELLS
5.5.3	FOOD LABELING

CLUSTER 6 HEALTH AND SAFETY

5.6.1	GROWTH CHART AND AREA MEASUREMENT
5.6.2	TOOTH CHART
5.6.3	SAFETY DEVICES
5.6.4	ALCOHOL, TOBACCO, AND DRUGS
5.6.5	SEXUALLY TRANSMITTED DISEASES
5.6.6	SEXUALLY TRANSMITTED DISEASE QUIZ
5.6.7	TOBACCO QUIZ
5.6.8	SMOKERS' SURVEY
5.6.9	EX-SMOKERS' SURVEY
5.6.10	SMOKING LAWS
5.6.11	ALCOHOL QUIZ
5.6.12	ALCOHOL LAWS
5.6.13	CHRIS'S STORY
5.6.14	THE PARENTS' STORY
5.6.15	INTOXICATION
5.6.16	DRUG LAWS

CLUSTER 7 WAYFINDING AND TRANSPORTATION

5.7.1	WHERE IN THE WORLD ARE WE?
5.7.2	PLANETARIUM
5.7.3	MAPPING THE SKY
5.7.4	THE NORTH POLE, EQUATOR, AND ECLIPTIC
5.7.5	WHERE IS EARTH?

CLUSTER 8 ENERGY AND COMMUNICATION

5.8.1	PUSHES, PULLS, AND FORCES
5.8.2	TEETER-TOTTERS
5.8.3	THE BALANCE
5.8.4	WHEELS AND AXLES
5.8.5	LEVERS: WHERE ARE THEY?
5.8.6	ARMS AND JAWS
5.8.7	INCLINED PLANES AND SCREWS
5.8.8	BLOCK AND TACKLE
5.8.9	FORCES PROJECTS

CLUSTER 9 CONSERVATION, RECYCLING, AND DECOMPOSITION

5.9.1	CLASS RECYCLING PROJECT
5.9.2	CLASS CONSERVATION PROJECT
5.9.3	DECOMPOSITION AND ARCHEOLOGY
5.9.4	POLLUTION PROJECT

CLUSTER 10 MATTER, SPACE, AND CONSTRUCTION

5.10.1	LINEAR MEASUREMENT
5.10.2	VOLUME MEASUREMENT
5.10.3	CAMERA OBSCURA
5.10.4	CONTROLLING LIGHT WITH LENSES
5.10.5	MAKING A TELESCOPE
5.10.6	STABILIZING THE TELESCOPE
5.10.7	MAKING A MICROSCOPE
5.10.8	MAKING A HYGROMETER
5.10.9	MAKING A BAROMETER

DASH 6
ACTIVITY LIST

CLUSTER 1 LEARNING

6.1.1 THE LEARNING CALENDAR
6.1.2 MARS MISSION
6.1.3 LAST YEAR
6.1.4 TOMORROW
6.1.5 THE WORK WORLD
6.1.6 GOALS
6.1.7 CRASH SIMULATION
6.1.8 MARS COMPACT
6.1.9 MARTIAN SIMULATION
6.1.10 THE MISSION CONFERENCE
6.1.11 CONCEPT AND SKILL INVENTORY

CLUSTER 2 TIME, WEATHER, AND SKY

6.2.1 WEATHER STATION
6.2.2 WEATHER AROUND THE UNITED STATES
6.2.3 WEATHER AND LOCAL CLIMATE
6.2.4 WIND HYPOTHESES
6.2.5 PRODUCING WINDS
6.2.6 AIR PRESSURE AND ALTITUDE
6.2.7 WIND AND WATER
6.2.8 ALTITUDE AND TEMPERATURE
6.2.9 MODELS OF AIR
6.2.10 CLIMATIC REGIONS
6.2.11 CLIMATE OF MARS

CLUSTER 3 ANIMALS

6.3.1 ANIMAL CARE
6.3.2 RAISING FISH
6.3.3 RAISING WORMS
6.3.4 FOOD CHAINS

CLUSTER 4 PLANTS

6.4.1 HYDROPONICS
6.4.2 ALGAE
6.4.3 NUTRIENTS AND BIOLOGICAL WASTE
6.4.4 WATER POLLUTANTS

CLUSTER 5 FOOD AND NUTRITION

6.5.1 NUTRIENT INFORMATION
6.5.2 THE KILOCALORIE
6.5.3 WEIGHT WATCHING
6.5.4 MEAL PLANNING
6.5.5 FOOD FOR SPACE
6.5.6 FISH FOR DINNER

CLUSTER 6 HEALTH AND SAFETY

6.6.1 GROWTH CHART
6.6.2 TOOTH CHART
6.6.3 SAFETY DEVICES
6.6.4 DISEASE LITERATURE
6.6.5 SANITATION
6.6.6 DISEASE-PRODUCING ORGANISMS
6.6.7 SEXUALLY TRANSMITTED DISEASES
6.6.8 DRUG ABUSE: PREVENTION AND TREATMENT
6.6.9 ALCOHOL AND TOBACCO
6.6.10 ENVIRONMENTAL DISEASE: TRANSMISSION, PREVENTION, AND TREATMENT
6.6.11 EXERCISE AND HEALTH AND THE MARS MISSION

CLUSTER 7 WAYFINDING AND TRANSPORTATION

6.7.1 FLYING AIRPLANES
FLYING ROCKETS
6.7.3 SPACECRAFT
6.7.4 THE ORBIT OF MARS
6.7.5 WHAT PATH TO MARS?

CLUSTER 8 ENERGY AND COMMUNICATION

6.8.1 ROCKET PROPULSION
6.8.2 MAGNETISM
6.8.3 ELECTROSTATICS
6.8.4 ELECTRICAL CIRCUITS
6.8.5 ROCK FORMATION
6.8.6 METALS FROM ROCK
6.8.7 ASYMMETRICAL LEVER

CLUSTER 9 CONSERVATION, RECYCLING, AND DECOMPOSITION

6.9.1 CLASS RECYCLING PROJECT
6.9.2 CONSERVATION
6.9.3 DECOMPOSITION: A SUMMARY
6.9.4 POLLUTION

CLUSTER 10 MATTER, SPACE, AND CONSTRUCTION

6.10.1 MAKING MEASURING EQUIPMENT
6.10.2 MAKING BALANCES
6.10.3 MAKING AN ELECTROSCOPE
6.10.4 MAKING ELECTROMAGNETS AND CURRENT INDICATORS
6.10.5 MAKING ELECTRIC CELLS
6.10.6 MAKING AN ELECTRIC MOTOR
6.10.7 MAKING AN ELECTRIC SIGNALER
6.10.8 MAKING A SURVIVAL HABITAT

DASH K–6
CLUSTER OUTLINES

CLUSTER ONE - LEARNING

GRADE KINDERGARTEN

K.1.1 THE LEARNING CALENDAR
K.1.2 THE CLASS RESPONSIBILITY CHART
K.1.3 CALENDAR REVIEW
K.1.4 THE HOME LEARNING CALENDAR
K.1.5 THE SCIENCE RECORD BOOK
K.1.6 USING OUR SENSES
K.1.7 SAME AND DIFFERENT
K.1.8 PHYSICAL CHARACTERISTICS OF THINGS
K.1.9 FUNCTIONS OF THINGS
K.1.10 THE WORKING DICTIONARY AND WORKING DEFINITIONS
K.1.11 THE WONDER AND DISCOVER BOOK
K.1.12 THE CONNECTIONS BOOK
K.1.13 FAMILIES
K.1.14 FAMILIES AND HELPING
K.1.15 MAKING FRIENDS
K.1.16 BEING FRIENDS
K.1.17 SCHOOL AND HOME
K.1.18 CONCEPT AND SKILL INVENTORY

GRADE ONE

1.1.1 THE LEARNING CALENDAR
1.1.2 THE RESPONSIBILITY CHART
1.1.3 THE PLANNING CALENDAR
1.1.4 THING LEARNED LAST YEAR
1.1.5 HELPING
1.1.6 WORKING TOGETHER
1.1.7 TAKING TURNS AND SHARING
1.1.8 CONCEPT AND SKILL INVENTORY

GRADE TWO

2.1.1 THE LEARNING CALENDAR
2.1.2 LAST YEAR
2.1.3 APHORISMS
2.1.4 HELPING MYSELF AND OTHERS
2.1.5 GETTING HELP
2.1.6 MAKING AND KEEPING FRIENDS
2.1.7 TURNS
2.1.8 SCHOOL, TEACHER, FRIENDS, AND FAMILY
2.1.9 PREDICTIONS ABOUT TOMORROW
2.1.10 PLANNING FOR TOMORROW
2.1.11 THINKING
2.1.12 LIBRARY
2.1.13 CONCEPT AND SKILL INVENTORY

GRADE THREE

3.1.1 THE LEARNING CALENDAR
3.1.2 LAST YEAR
3.1.3 RESPONSIBILITY
3.1.4 PLANNING
3.1.5 ORGANIZING OUR ENVIRONMENT
3.1.6 FRIENDS
3.1.7 GIVING AND RECEIVING
3.1.8 WORKING TOGETHER
3.1.9 HELPING MYSELF AND OTHERS
3.1.10 APHORISMS
3.1.11 NEXT YEAR
3.1.12 CAREY'S GARDEN
3.1.13 CONCEPT AND SKILL INVENTORY

GRADE FOUR

4.1.1 THE LEARNING CALENDAR
4.1.2 RESPONSIBILITY
4.1.3 LAST YEAR
4.1.4 THE LIBRARY
4.1.5 WORKING TOGETHER
4.1.6 THINGS I CAN DO FOR MYSELF AND FOR OTHERS
4.1.7 APHORISMS
4.1.8 PLANNING
4.1.9 SURVIVAL GAME
4.1.10 CONCEPT AND SKILL INVENTORY

GRADE FIVE

5.1.1 THE LEARNING CALENDAR
5.1.2 RESPONSIBILITY
5.1.3 LIBRARY CHECK-OUT
5.1.4 LIBRARY CHECK-IN
5.1.5 WORKING TOGETHER
5.1.6 THINGS I CAN DO FOR MYSELF AND OTHERS
5.1.7 APHORISMS
5.1.8 FRIENDSHIP
5.1.9 CONCEPT AND SKILL INVENTORY

GRADE SIX

6.1.1 THE LEARNING CALENDAR
6.1.2 MARS MISSION
6.1.3 LAST YEAR
6.1.4 TOMORROW
6.1.5 THE WORK WORLD
6.1.6 GOALS
6.1.7 CRASH SIMULATION
6.1.8 MARS COMPACT
6.1.9 MARTIAN SIMULATION
6.1.10 THE MISSION CONFERENCE
6.1.11 CONCEPT AND SKILL INVENTORY

CLUSTER TWO - TIME, WEATHER, AND SKY

GRADE KINDERGARTEN

K.2.1 WEATHER WATCH
K.2.2 BEGINNINGS
K.2.3 ENDINGS
K.2.4 DAY AND NIGHT
K.2.5 DAYS, WEEKS, AND MONTHS
K.2.6 MOON WATCH
K.2.7 MOON PHASES
K.2.8 SEASONS
K.2.9 CLOCKS AND CALENDARS

GRADE ONE

1.2.1 SKY AND WEATHER WATCH
1.2.2 RAIN AND STREAMS
1.2.3 SNOW AND STREAMS
1.2.4 THE DIGITAL CLOCK
1.2.5 HOURS AND MINUTES
1.2.6 TIME LINE
1.2.7 SUNRISE AND SUNSET
1.2.8 NIGHT AND DAY
1.2.9 THE SUN
1.2.10 THE SEASONS
1.2.11 MAKING A CLOCK
1.2.12 MOONRISE AND MOON SET

GRADE TWO

2.2.1 TEMPERATURE
2.2.2 WIND
2.2.3 SUNRISE, SUNSET, AND SEASONS
2.2.4 MOONRISE AND MOONSET
2.2.5 RAIN
2.2.6 SNOW
2.2.7 DIGITAL TIME
2.2.8 ANALOG TIME

GRADE THREE

3.2.1 WEATHER
3.2.2 TEMPERATURE
3.2.3 WIND
3.2.4 RAIN AND SNOW
3.2.5 HUMIDITY
3.2.6 SUNRISE AND SUNSET
3.2.7 MOON PHASES
3.2.8 POLAR SKY MODEL
3.2.9 POLAR CONSTELLATIONS
3.2.10 VENUS
3.2.11 ECLIPSES

GRADE FOUR

4.2.1 RAINFALL
4.2.2 SNOWFALL
4.2.3 WIND DIRECTION
4.2.4 WIND SPEED
4.2.5 HEIGHT OF CLOUDS
4.2.6 HUMIDITY
4.2.7 CLOUDS AND WEATHER
4.2.8 STORM CLOUDS
4.2.9 LIGHTNING
4.2.10 WEATHER MAPS
4.2.11 WEATHER FRONTS
4.2.12 PREDICTING WEATHER
4.2.13 WIND CHILL
4.2.14 FLAT OR ROUND EARTH
4.2.15 LENGTH OF DAY AND NIGHT
4.2.16 THE SUN'S SHADOW PATH
4.2.17 PLANETARIUM
4.2.18 USING THE PLANETARIUM
4.2.19 PLANETS
4.2.20 WHEN IS IT NOON?
4.2.21 MAKING A SUNDIAL
4.2.22 USING A SUNDIAL
4.2.23 SEASONS AND THE SUN
4.2.24 MOON PHASES AND THE SUN
4.2.25 ECLIPSES

GRADE FIVE

5.2.1 WEATHER STATION
5.2.2 HEAT INDEX
5.2.3 WEATHER AND ITS PREDICTION
5.2.4 CLOUDS AND FRONTS
5.2.5 TRIANGLES
5.2.6 GNOMON
5.2.7 SIZE OF EARTH
5.2.8 MOON THROUGH A TELESCOPE
5.2.9 HOW BIG AND FAR AWAY IS THE MOON?
5.2.10 PATHS OF CELESTIAL BODIES
5.2.11 MODELS OF THE SOLAR SYSTEM

GRADE SIX

6.2.1 WEATHER STATION
6.2.2 WEATHER AROUND THE UNITED STATES
6.2.3 WEATHER AND LOCAL CLIMATE
6.2.4 WIND HYPOTHESES
6.2.5 PRODUCING WINDS
6.2.6 AIR PRESSURE AND ALTITUDE
6.2.7 WIND AND WATER
6.2.8 ALTITUDE AND TEMPERATURE
6.2.9 MODELS OF AIR
6.2.10 CLIMATIC REGIONS
6.2.11 CLIMATE OF MARS

CLUSTER THREE - ANIMALS

GRADE KINDERGARTEN

K.3.1 APPROPRIATE PETS
K.3.2 CLASSROOM ANIMALS
K.3.3 CARING FOR CLASSROOM ANIMALS
K.3.4 LIVING, ONCE-LIVING, AND NOT-LIVING
K.3.5 ANIMALS AND PLANTS
K.3.6 ANIMAL ENVIRONMENTS
K.3.7 USES FOR ANIMALS
K.3.8 HOW BUGS WALK
K.3.9 PARTS OF BUGS
K.3.10 PARTS OF MAMMALS
K.3.11 PEOPLE
K.3.12 ANIMALS AND FOOD
K.3.13 ANIMALS AND WATER
K.3.14 ANIMALS AND AIR
K.3.15 ANIMAL WASTES
K.3.16 HOW ANIMALS KEEP WARM
K.3.17 HOW ANIMALS KEEP COOL
K.3.18 REAL OR IMAGINARY

GRADE ONE

1.3.1 LIVING AND NOT-LIVING THINGS
1.3.2 DEFINING LIVING AND NOT-LIVING THINGS
1.3.3 ANIMAL SURVEY
1.3.4 ANIMAL KEY
1.3.5 ANIMAL NEEDS
1.3.6 PLANNING TO RAISE A SMALL ANIMAL
1.3.7 BUILDING CAGES
1.3.8 METAMORPHOSIS
1.3.9 CLASSROOM PETS

GRADE TWO

2.3.1 THE CLASSROOM AQUARIUM
2.3.2 EXTERNAL ANATOMY OF FISH
2.3.3 BIOLOGICAL NEEDS OF FISH
2.3.4 REPRODUCTION AND DEVELOPMENT OF FISH
2.3.5 FINDING INSECT EGGS
2.3.6 HATCHING INSECT EGGS
2.3.7 EARLY METAMORPHOSIS
2.3.8 LATE METAMORPHOSIS
2.3.9 COLLECTING SPIDERS
2.3.10 SPIDER FOOD
2.3.11 SPIDER CARE
2.3.12 SPIDERS AS PREDATORS
2.3.13 SPIDER WEBS
2.3.14 CLASSROOM PETS

GRADE THREE

3.3.1 CLASSROOM PETS
3.3.2 PREPARING TO RAISE INSECTS
3.3.3 RAISING INSECTS
3.3.4 IMPORTANCE OF INSECTS
3.3.5 NATURAL HABITATS OF FROGS AND TOADS
3.3.6 MAKING HABITATS FOR FROGS AND TOADS
3.3.7 FROG METAMORPHOSIS
3.3.8 IMPORTANCE OF FROGS AND TOADS
3.3.9 TOADS AND INSECTS
3.3.10 HATCHING CHICKS
3.3.11 CHICK GROWTH
3.3.12 IMPORTANCE OF BIRDS

GRADE FOUR

4.3.1 PET CARE
4.3.2 THE UNINCUBATED EGG
4.3.3 CHICK EMBRYOLOGY
4.3.4 RAISING SMALL MAMMALS
4.3.5 HOUSING PET MAMMALS
4.3.6 WEEKEND CARE OF PET MAMMALS
4.3.7 PAIRING PET MAMMALS
4.3.8 REPRODUCTION OF PET MAMMALS
4.3.9 PET BABY CARE
4.3.10 OUR EARLY YEARS
4.3.11 THE FIRST GRADE CHILD
4.3.12 GROWTH, DEVELOPMENT, AND BEHAVIOR OF YOUNG PETS
4.3.13 HUMAN GROWTH AND DEVELOPMENT
4.3.14 CHANGING DIMENSIONS
4.3.15 EXTERNAL ANATOMY OF FISH
4.3.16 CLEANING FISH: INTERNAL ANATOMY
4.3.17 FISH REPRODUCTION
4.3.18 MODELING OUR DIGESTIVE SYSTEM
4.3.19 OUR DIGESTIVE SYSTEM IN TWO DIMENSIONS
4.3.20 DIGESTIVE, CIRCULATORY, AND RESPIRATORY SYSTEMS
4.3.21 LENGTH OF THE DIGESTIVE TRACT
4.3.22 MIGRATION AND HIBERNATION
4.3.23 FALL BIRDS
4.3.24 WINTER BIRDS
4.3.25 SPRING BIRDS

GRADE FIVE

5.3.1 PET CARE
5.3.2 BIRD FEEDER
5.3.3 BIRDS I KNOW
5.3.4 CELLS
5.3.5 CELL QUIZ
5.3.6 MALE UROGENITAL SYSTEM
5.3.7 FEMALE UROGENITAL SYSTEM
5.3.8 OVULATION CYCLE
5.3.9 OVULATION AND PREGNANCY
5.3.10 EMBRYOLOGY
5.3.11 BODY CHANGES
5.3.12 BONES
5.3.13 SKELETAL SYSTEM
5.3.14 MUSCLES
5.3.15 MUSCULAR SYSTEM
5.3.16 CHEMISTRY AND BONES
5.3.17 THE SENSES
5.3.18 THE EYE
5.3.19 SOUND
5.3.20 THE EAR

GRADE SIX

6.3.1 ANIMAL CARE
6.3.2 RAISING FISH
6.3.3 RAISING WORMS
6.3.4 FOOD CHAINS

CLUSTER FOUR - PLANTS

GRADE KINDERGARTEN

K.4.1 PLANT PARTS
K.4.2 PLANT ENVIRONMENTS
K.4.3 PLANT USES
K.4.4 GROWING BEAN SPROUTS
K.4.5 PLANTS AND WATER
K.4.6 GARDENING

GRADE ONE

1.4.1 PLANT IDENTIFICATION
1.4.2 PLANT SURVEY
1.4.3 PLANT PRESSING
1.4.4 PLANT KEY
1.4.5 PLANT NEEDS
1.4.6 PLANT LIFE CYCLE
1.4.7 EDIBLE PLANT PARTS
1.4.8 PLANT PARTS ANIMALS EAT

GRADE TWO

2.4.1 SOIL
2.4.2 MAKING SOIL
2.4.3 SOIL AND PLANTS
2.4.4 SOIL USES
2.4.5 FINDING SOIL
2.4.6 PIPES AND WATER
2.4.7 MOVING WATER
2.4.8 MOVING WATER WITH PUMPS
2.4.9 VEGETABLE GARDEN IN A BUCKET
2.4.10 FLOWER GARDEN IN A BUCKET
2.4.11 PLANTS AND SUNLIGHT
2.4.12 ROOTING STEMS
2.4.13 ROOTING BULBS AND TUBERS
2.4.14 ROOTS AND WATER
2.4.15 GROWING ROOT VEGETABLES
2.4.16 TREE PLANTING

GRADE THREE

3.4.1 GARDEN PLANNING
3.4.2 GARDEN PREPARATION
3.4.3 WATCHING GARDEN SOIL
3.4.4 MAKING ARTIFICIAL SOIL
3.4.5 TESTING ARTIFICIAL SOIL
3.4.6 SOIL AND WATER
3.4.7 GARDEN PLANTING
3.4.8 GARDEN CARE
3.4.9 GARDEN WATERING SYSTEMS
3.4.10 GARDEN INVADERS
3.4.11 CONTROLLING INSECTS
3.4.12 GARDEN HARVESTING
3.4.13 FLOWERS
3.4.14 SEEDS
3.4.15 POLLINATION

GRADE FOUR

4.4.1 ANNUAL, BIENNIAL, AND PERENNIAL GARDEN PLANTS
4.4.2 THE FUNGUS AMONG US
4.4.3 FUNGUS COLLECTION

GRADE FIVE

5.4.1 ANNUAL, BIENNIAL, AND PERENNIAL PLANT PROJECT
5.4.2 TREE HARVESTING
5.4.3 TREE PLANTING
5.4.4 TREE OBSERVATION
5.4.5 MEASURING TREES
5.4.6 AGE OF TREES
5.4.7 TREES, SHRUBS, AND GRASSES
5.4.8 GRASSES: WHY DO THEY GROW THERE?
5.4.9 ROOTS
5.4.10 SOIL CONSERVATION

GRADE SIX

6.4.1 HYDROPONICS
6.4.2 ALGAE
6.4.3 NUTRIENTS AND BIOLOGICAL WASTE
6.4.4 WATER POLLUTANTS

CLUSTER FIVE - FOOD AND NUTRITION

GRADE KINDERGARTEN

K.5.1 BEAN SPROUT SALAD
K.5.2 DRINKS
K.5.3 FLOUR AND BREAD
K.5.4 FAMILIAR FOODS
K.5.5 FAVORITE FOODS
K.5.6 NEW FOODS
K.5.7 SNACKS FROM THE GARDEN

GRADE ONE

1.5.1 BASIC THREE FOOD GROUPS
1.5.2 COOKING
1.5.3 MEASURING VOLUME

GRADE TWO

2.5.1 SUPERMARKET SURVEY
2.5.2 FOOD PREFERENCES
2.5.3 BASIC THREE FOOD GROUPS
2.5.4 NEW FOODS
2.5.5 IDENTIFYING PROPERTIES OF VEGETABLES
2.5.6 CHANGING FLAVOR
2.5.7 MILK
2.5.8 BUTTER
2.5.9 CHEESE
2.5.10 ENERGY FROM FOOD

GRADE THREE

3.5.1 FOOD SELECTION
3.5.2 SELECTING PLANTS FOR THE GARDEN
3.5.3 PLANNING THE CLASS FEAST
3.5.4 PREPARING THE CLASS FEAST
3.5.5 THE CLASS FEAST
3.5.6 DRYING FOODS
3.5.7 PICKLING FOODS
3.5.8 PRESERVING AND ROTTING
3.5.9 SUPERMARKET GAME PREPARATION
3.5.10 PRICING FOODS
3.5.11 NEWSPAPER ADS AND BANKING
3.5.12 FARMERS AND PROCESSORS
3.5.13 SUPERMARKET GAME

GRADE FOUR

4.5.1 NUTRITION MESSAGES
4.5.2 MECHANICAL DIGESTION
4.5.3 CHEMICAL DIGESTION
4.5.4 FOOD GROUPS
4.5.5 DIGESTION GAME
4.5.6 PRESERVING FOODS

GRADE FIVE

5.5.1 NUTRIENTS
5.5.2 NUTRIENTS AND CELLS
5.5.3 FOOD LABELING

GRADE SIX

6.5.1 NUTRIENT INFORMATION
6.5.2 THE KILOCALORIE
6.5.3 WEIGHT WATCHING
6.5.4 MEAL PLANNING
6.5.5 FOOD FOR SPACE
6.5.6 FISH FOR DINNER

CLUSTER SIX - HEALTH AND SAFETY

GRADE KINDERGARTEN

K.6.1 GROWTH CHART
K.6.2 TOOTH CHART
K.6.3 TOOTH CARE
K.6.4 EXERCISE
K.6.5 GERMS
K.6.6 WASHING HANDS
K.6.7 BATHROOMS AND BASINS
K.6.8 APRONS
K.6.9 FOUNTAINS AND FAUCETS
K.6.10 GETTING SICK
K.6.11 FEELING SICK
K.6.12 GOING TO THE DOCTOR
K.6.13 WHAT DOCTORS DO
K.6.14 GOING TO THE HOSPITAL
K.6.15 RAINCOATS
K.6.16 TESTING RAINCOATS
K.6.17 WET AND COLD
K.6.18 KEEPING WARM INDOORS
K.6.19 KEEPING COOL INDOORS
K.6.20 HAND AND FOOT PROTECTION
K.6.21 GETTING LOST

GRADE ONE

1.6.1 GROWTH CHART
1.6.2 TOOTH CHART
1.6.3 BRUSHING TEETH
1.6.4 CHEWING
1.6.5 AIR AND BREATHING
1.6.6 GETTING HURT
1.6.7 STAYING HEALTHY
1.6.8 SAFETY RULES

GRADE TWO

2.6.1 GROWTH CHART
2.6.2 TOOTH CHART
2.6.3 TOOTH CARE
2.6.4 GETTING HURT
2.6.5 GETTING SICK
2.6.6 STAYING WELL
2.6.7 CLASSROOM AND PLAYGROUND SAFETY
2.6.8 FIRE SAFETY
2.6.9 USING 911

GRADE THREE

3.6.1 GROWTH CHART
3.6.2 TOOTH CHART
3.6.3 BREATHING AIR
3.6.4 ANATOMY OF BREATHING
3.6.5 LUNG MODEL
3.6.6 LUNGS AND SMOKING
3.6.7 BREATHING AND PULSE RATES
3.6.8 HEART, VEINS, AND ARTERIES
3.6.9 HEART, LUNGS, AND EXERCISE
3.6.10 DISEASE TRANSMISSION
3.6.11 TRASH AND SANITATION
3.6.12 HELPFUL DRUGS
3.6.13 PROPER DRUG USE

GRADE FOUR

4.6.1 GROWTH CHART AND AREA MEASUREMENT
4.6.2 TOOTH CHART
4.6.3 SAFETY GEAR
4.6.4 SAFETY AND PUTTING OUT FIRES
4.6.5 MAKING A FIRE
4.6.6 THINGS THAT BURN
4.6.7 SMOKING AND THE LUNGS
4.6.8 ALCOHOL, TOBACCO, AND DRUGS

GRADE FIVE

5.6.1 GROWTH CHART AND AREA MEASUREMENT
5.6.2 TOOTH CHART
5.6.3 SAFETY DEVICES
5.6.4 ALCOHOL, TOBACCO, AND DRUGS
5.6.5 SEXUALLY TRANSMITTED DISEASES
5.6.6 SEXUALLY TRANSMITTED DISEASE QUIZ
5.6.7 TOBACCO QUIZ
5.6.8 SMOKERS' SURVEY
5.6.9 EX-SMOKERS' SURVEY
5.6.10 SMOKING LAWS
5.6.11 ALCOHOL QUIZ
5.6.12 ALCOHOL LAWS
5.6.13 CHRIS'S STORY
5.6.14 THE PARENTS' STORY
5.6.15 INTOXICATION
5.6.16 DRUG LAWS

GRADE SIX

6.6.1 GROWTH CHART
6.6.2 TOOTH CHART
6.6.3 SAFETY DEVICES
6.6.4 DISEASE LITERATURE
6.6.5 SANITATION
6.6.6 DISEASE-PRODUCING ORGANISMS
6.6.7 SEXUALLY TRANSMITTED DISEASES
6.6.8 DRUG ABUSE: PREVENTION AND TREATMENT
6.6.9 ALCOHOL AND TOBACCO
6.6.10 ENVIRONMENTAL DISEASE : TRANSMISSION, PREVENTION, AND TREATMENT
6.6.11 EXERCISE AND HEALTH AND THE MARS MISSION

CLUSTER SEVEN - WAYFINDING AND TRANSPORTATION

GRADE KINDERGARTEN

K.7.1	RIGHT AND LEFT
K.7.2	SUNRISE
K.7.3	SUNSET
K.7.4	NORTH AND SOUTH
K.7.5	HOME LOCATION
K.7.6	SIDEWALKS AND WALKWAYS
K.7.7	ROADS
K.7.8	TRAFFIC SIMULATION EQUIPMENT
K.7.9	TRAFFIC SIMULATION MAPPING
K.7.10	TRAFFIC SIMULATION RULES
K.7.11	CLASSROOM MAPPING

GRADE ONE

1.7.1	PACING
1.7.2	NORTH, SOUTH, EAST, AND WEST
1.7.3	HOME
1.7.4	MAP DISTANCE
1.7.5	MAKING A BOAT
1.7.6	MAKING A LAKE
1.7.7	THE GREAT REGATTA
1.7.8	FLOATING AND SINKING
1.7.9	DRAINING A LAKE

GRADE TWO

2.7.1	TRANSPORTATION SYSTEMS
2.7.2	MAKING RACE CARS
2.7.3	RACING AND MODIFYING CARS
2.7.4	ROADS
2.7.5	BUILDING A VILLAGE
2.7.6	PEDESTRIANS IN THE VILLAGE
2.7.7	BIKES IN THE VILLAGE
2.7.8	CARS IN THE VILLAGE
2.7.9	BIKES AND TRIKES
2.7.10	BELTS AND PULLEYS
2.7.11	FAST AND SLOW PULLEYS
2.7.12	GEARS AND WHEELS

GRADE THREE

3.7.1	GARDEN MOVER
3.7.2	PROPELLER-DRIVEN MESSAGE CENTER
3.7.3	PROPELLER-DRIVEN BOAT
3.7.4	DELIVERY SYSTEMS

GRADE FOUR

4.7.1	BOAT DESIGN
4.7.2	WIND AND SAILS

GRADE FIVE

5.7.1	WHERE IN THE WORLD ARE WE?
5.7.2	PLANETARIUM
5.7.3	MAPPING THE SKY
5.7.4	THE NORTH POLE, EQUATOR, AND ECLIPTIC
5.7.5	WHERE IS EARTH?

GRADE SIX

6.7.1	FLYING AIRPLANES
6.7.2	FLYING ROCKETS
6.7.3	SPACECRAFT
6.7.4	THE ORBIT OF MARS
6.7.5	WHAT PATH TO MARS?

CLUSTER EIGHT - ENERGY AND COMMUNICATION

GRADE KINDERGARTEN

K.8.1	ENERGY
K.8.2	MAKING THINGS MOVE
K.8.3	MAKING THINGS STOP
K.8.4	TURNING THINGS OFF
K.8.5	TURNING THINGS ON
K.8.6	REPAIRING THINGS

GRADE ONE

1.8.1	TEMPERATURE OF THINGS
1.8.2	THE MASTER THERMOMETER
1.8.3	HOT AND COLD
1.8.4	SOURCES OF ENERGY

GRADE TWO

2.8.1	CAMERA OBSCURA
2.8.2	MIRRORS AND SUNLIGHT
2.8.3	CLOUDS AND SUNLIGHT
2.8.4	COMPARING TEMPERATURES
2.8.5	ECLIPSES

GRADE THREE

3.8.1	SHADOW, LIGHT, AND BUBBLES
3.8.2	WIND AND HEAT
3.8.3	WIND PULLS AND PUSHES
3.8.4	PROPELLERS DRIVING PROPELLERS
3.8.5	WATERWHEELS
3.8.6	PROPELLERS IN WATER
3.8.7	HELIOGRAPH
3.8.8	SPEAKING TUBE
3.8.9	STRING TELEPHONE
3.8.10	ENERGY DEFINTIONS

GRADE FOUR

4.8.1	PUSH-PULL MEASURING TOOL
4.8.2	FRICTION
4.8.3	STREAMLINING
4.8.4	PRESSURE, SHARP EDGES, AND POINTS
4.8.5	ENERGY OF FALLING OBJECTS
4.8.6	CIRCLES AND SPEED

GRADE FIVE

5.8.1	PUSHES, PULLS, AND FORCES
5.8.2	TEETER-TOTTERS
5.8.3	THE BALANCE
5.8.4	WHEELS AND AXLES
5.8.5	LEVERS: WHERE ARE THEY?
5.8.6	ARMS AND JAWS
5.8.7	INCLINED PLANES AND SCREWS
5.8.8	BLOCK AND TACKLE
5.8.9	FORCES PROJECTS

GRADE SIX

6.8.1	ROCKET PROPULSION
6.8.2	MAGNETISM
6.8.3	ELECTROSTATICS
6.8.4	ELECTRICAL CIRCUITS
6.8.5	ROCK FORMATION
6.8.6	METALS FROM ROCK
6.8.7	ASYMMETRICAL LEVER

CLUSTER NINE - CONSERVATION, RECYCLING AND DECOMPOSITION

GRADE KINDERGARTEN

K.9.1	DECOMPOSITION
K.9.2	WASTE DISPOSAL
K.9.3	RECYCLING PROJECT
K.9.4	MAKING PAPER

GRADE ONE

1.9.1	CONSERVING CLASSROOM RESOURCES
1.9.2	CONSERVING ENERGY
1.9.3	CONSERVING WATER
1.9.4	DECOMPOSITION AND UNEARTHING
1.9.5	DECOMPOSITION AND REBURIAL
1.9.6	RECYCLING

GRADE TWO

2.9.1	FALL UNEARTHING
2.9.2	FALL BURYING
2.9.3	SPRING UNEARTHING
2.9.4	SPRING BURYING
2.9.5	POLLUTION SURVEY AND CLEANUP
2.9.6	ALUMINUM RECYCLING
2.9.7	CONNECTIONS

GRADE THREE

3.9.1	MAKING COMPOST
3.9.2	WATCHING COMPOST
3.9.3	ANIMALS IN COMPOST
3.9.4	USING COMPOST
3.9.5	FALL UNEARTHING AND BURIAL
3.9.6	SPRING UNEARTHING AND BURIAL

GRADE FOUR

4.9.1	UNEARTHING AND BURIAL
4.9.2	RECYCLING PROJECT

GRADE FIVE

5.9.1	CLASS RECYCLING PROJECT
5.9.2	CLASS CONSERVATION PROJECT
5.9.3	DECOMPOSITION AND ARCHEOLOGY
5.9.4	POLLUTION PROJECT

GRADE SIX

6.9.1	CLASS RECYCLING PROJECT
6.9.2	CONSERVATION
6.9.3	DECOMPOSITION: A SUMMARY
6.9.4	POLLUTION

CLUSTER TEN - MATTER SPACE, AND CONSTRUCTION

GRADE KINDERGARTEN

K.10.1	CUBBY ORGANIZATION
K.10.2	PATTERNS IN PUZZLES
K.10.3	MAKING PUZZLES
K.10.4	MAKING ENVELOPES
K.10.5	MAKING BOXES AND BAGS
K.10.6	VOLUME OF BOXES AND BAGS
K.10.7	PACKING AND STORING
K.10.8	LINEAR MEASUREMENT

GRADE ONE

1.10.1	METER-STRING CAN
1.10.2	OUTDOOR STUDY AREA MAPPING
1.10.3	TESTING FOR WATER
1.10.4	PLUMBING
1.10.5	WATER SYSTEMS
1.10.6	AIR
1.10.7	BUBBLES IN WATER
1.10.8	BUBBLES IN AIR
1.10.9	BUILDING WITH AIR
1.10.10	FLOOR PLAN
1.10.11	FLOOR PLAN MODEL
1.10.12	CARDBOARD HOUSE PLAN
1.10.13	MAKING A CARDBOARD HOUSE
1.10.14	PAINTING THE HOUSE
1.10.15	FURNISHING THE HOUSE
1.10.16	SEWING
1.10.17	WEAVING
1.10.18	WARMING AND COOLING THE HOUSE
1.10.19	LIGHTING THE HOUSE
1.10.20	SAFETY EQUIPMENT

GRADE TWO

2.10.1	DESK ORGANIZATION
2.10.2	NOTEBOOK ORGANIZATION
2.10.3	THE BALANCE
2.10.4	METER-STRING CAN
2.10.5	MEASURING VOLUME
2.10.6	SAFETY EQUIPMENT

GRADE THREE

3.10.1	ACIDIC AND BASIC SOIL
3.10.2	ACIDS AND BASES
3.10.3	ACID AND BASE REACTIONS
3.10.4	DILUTING ACIDS AND BASES
3.10.5	ACID AND BASE INTERACTION
3.10.6	DISSOLVING THINGS
3.10.7	THINGS IN LIQUIDS
3.10.8	CRYSTALS
3.10.9	RAIN IN A JAR
3.10.10	SUPERMARKET PLANNING
3.10.11	SUPERMARKET CONSTRUCTION
3.10.12	MEASURING DEVICES
3.10.13	SAFETY EQUIPMENT

GRADE FOUR

4.10.1	LINEAR MEASUREMENT
4.10.2	VOLUME MEASUREMENT
4.10.3	MASS MEASUREMENT
4.10.4	COLLECTING ROCKS
4.10.5	HARDNESS OF ROCKS
4.10.6	SPECIFIC GRAVITY
4.10.7	ROCKS AND SHARP EDGES
4.10.8	MAKING TOOLS FROM ROCK
4.10.9	MAKING FISHING TOOLS
4.10.10	CLOWNS:THINGS THAT FLOAT
4.10.11	CLAY
4.10.12	FIRE AND POTTERY
4.10.13	AIR AND FIRE
4.10.14	FIRE AND OXYGEN
4.10.15	PROPERTIES OF GASES

GRADE FIVE

5.10.1	LINEAR MEASUREMENT
5.10.2	VOLUME MEASUREMENT
5.10.3	CAMERA OBSCURA
5.10.4	CONTROLLING LIGHT WITH LENSES
5.10.5	MAKING A TELESCOPE
5.10.6	STABILIZING THE TELESCOPE
5.10.7	MAKING A MICROSCOPE
5.10.8	MAKING A HYGROMETER
5.10.9	MAKING A BAROMETER

GRADE SIX

6.10.1	MAKING MEASURING EQUIPMENT
6.10.2	MAKING BALANCES
6.10.3	MAKING AN ELECTROSCOPE
6.10.4	MAKING ELECTROMAGNETS AND CURRENT INDICATORS
6.10.5	MAKING ELECTRIC CELLS
6.10.6	MAKING AN ELECTRIC MOTOR
6.10.7	MAKING AN ELECTRIC SIGNALER
6.10.8	MAKING A SURVIVAL HABITAT

DASH

DASH GRADE 5
MATERIALS

DASH
GRADE 5
MATERIALS

Philosophy

DASH assumes that in the beginning stages of science and technology study students should be able to do the same things at home that they do at school. Throughout DASH students are encouraged to extend their school observations, investigations, and construction beyond the classroom and schoolyard. Basic science and technology should not be made inaccessible by and enshrouded in the mystery of a teacher-controlled store of special equipment. Therefore, almost all the materials used in DASH are commonplace items students can find on their own outside of school. In grade 5 the exceptions are telescope lenses and cobalt chloride and pH paper. Even here, small thumbnail-sized pieces of indicator papers shared with students will last a semester at home.

Lack of specific items should not hinder the study. If items are not available, you and your students can often invent substitute equipment or simply do other activities.

Computers, overhead projectors, and other audiovisual equipment are not found on the materials list. If the school has them, they should be used where appropriate. Since 1995 DASH training has included instruction in accessing the Internet. Where computer equipment exists, classes can take advantage of interschool exchanges of information.

Materials

The materials for DASH activities have been divided into three categories— permanent, expendable, and salvage. *Permanent* items will last for years if students give attention to maintenance. Many permanent items may be part of the school's normal equipment list. *Expendable* items will usually be purchased each year, though a supply of paint, cobalt chloride and pH paper, pins, and thumbtacks may last for several years. *Salvage* items can be brought from home by the students as part of their contribution to the inquiry. These are recyclables that reinforce the idea of reuse of discards.

Storage

Where possible the problem of storage of materials and equipment should be shared with the students. Well-marked cardboard boxes can be stacked to hold most items. Assignment of *equipment teams* to collect and be responsible for stocking specific salvage items reinforces the message that neat, labeled, organized storage makes work safer, more efficient, and aesthetically pleasing.

Cleaning of Salvage

Items that are brought from home should be inspected to be sure that they are clean and usable. Periodically time should be allocated to inspect materials and attend to their cleaning, repacking, and discard when worn out.

Quantities of Materials

The amount of material needed in each activity will be determined by four factors—the inventiveness of the students, the degree to which conservation is practiced, the amount of material available, and the number of students needing material. It is usually more effective to be generous with materials in the beginning, then over time through class discussion get consensus on the need to conserve supplies. Conservation becomes the students' own objective.

Access to Supplies

In certain DASH activities you may wish to limit the students' access to supplies to bring a focus to their invention. This can be done by putting a limited number of items in the Inventor's Box. Once students are used to the routine of returning items to storage, a policy of general access to supplies may develop. This will be helped by having an *equipment restocking team* to reassemble equipment at the end of an activity.

There are some items that should always be available in anticipation of serendipitous opportunities to explore. These items include hand lenses, indicator papers, thermometers, and student-made metric measuring equipment, tapes, graduates, and balances.

Materials Lists

There are two different forms of the materials lists. One appears in each activity under the heading "Materials." The General Materials List given here is an alphabetical listing of materials that will be used over the course of the year.

GRADE 5
GENERAL MATERIALS LIST

Permanent
anatomic charts/torso
binoculars/opera glasses
buckets
camera
drawing compasses
eyeglass lenses (asstd)
flashlights
glue gun
hammers
hand lenses
hand saw
hose, garden
maps, U.S., state, local
magnets
magnetic compasses
metric rulers, 3-hole
metersticks
mirrors, small, hand
plastic pipe, 1/2-in
pliers
protractor
rope, lightweight
scale, bathroom
scissors
shovel
side cutters
serrated knives
telescope lenses
tennis balls
thermometers
World Almanac

Expendables
adding machine tape
aluminum foil
balloons (asstd)
birdseed
bolts, nuts, screws (asstd)
brads
bulbs, flashlight, 1.5V

Expendables (Cont.)
calendar paper
chart/butcher paper
cobalt chloride paper
cups, plastic 9-oz transparent
dry-cell batteries 1.5V
duct tape
glue
graph paper (centimeter)
iodine
index cards, 3 x 5 lined
iron filings
marbles, clear colorless
markers, colored
markers, permanent (asstd)
masking tape
modeling clay
nails (asstd)
needles and pins (asstd)
paint, water-based
paper clips, small
paper clips, jumbo
pH paper
plastic wrap
plastic bags, garbage
plastic bags, sealable (qt)
plastic bags, sealable (gal)
plastic sealant
plastic tape, write-on
razor, single-blade
rubber bands (asstd)
salt
skewers, barbecue
straws
string, cotton
string, nylon
sugar, powdered
thumbtacks
toothpicks
vinegar
washers (asstd)
wax (canning)
waxed paper

Salvage
aluminum pie pans
bleach bottles, plastic (gal)
bricks
cans, coffee with plastic lids
cans (1/2–1 gal)
cans, small
cans, tuna
cardboard, corrugated
cardboard shoe boxes
cardboard soda can holders
cardboard tubes
cement blocks
chopsticks
cloths
clothespins
coat hangers, wire
combs
film canisters, clear
film canisters, opaque
hacksaw blades
jars, baby food
jars (qt)
jars (gal)
jars with lids, misc. shapes
jar lids (asstd)
milk cartons (asstd)
newspaper
paper bags
plastic bottles with caps (asstd)
plastic milk jugs
plywood (asstd pieces)
screening, used
stockings, nylon
sticks and dowels (asstd)
Styrofoam pieces (asstd)
wax, canning
wooden boards (asstd)
yarn (asstd)